CHAPTER THREE

CATEGORY 1, WATER QUALITY

INTRODUCTION AND ISSUES IDENTIFICATION

Jamaica Bay is one of the largest tidal and most important wetland complexes in New York State. It is located on the Atlantic Coastal Flyway bird migration route and provides ample resources for food and shelter for at least 325 bird species, 91 species of fish and 54 species of moths and butterflies. Jamaica Bay remains a vibrant local and regional ecological resource in spite of the many significant biological physical and chemical changes to the Bay and its watershed over the last 150 years. Listed below are some of the more important physical and chemical changes that have occurred:

- Over 12,000 acres of the original 16,000 acres of wetlands within Jamaica Bay have been lost due to filling operations.
- Natural shallow waterways of approximately 12 ft to 20 ft have been dredged to depths of 40 ft to 50 ft in some locations to allow for navigation needs and to provide fill material for upland development projects. An estimated 125 million cubic yards of sand have been removed from the Bay.
- Tidal exchange with the Atlantic Ocean has been altered by the filling of inlet connections to the ocean in the southeastern portion of the Rockaway Peninsula (Sommerville Basin – "Gateway to the Atlantic") and constriction of the western end due to the natural extension of the western spit by nearly 16,000 ft (three miles) over the last 125 years.
- Receives approximately 259 million gallons per day (Fiscal Year 2006) of treated effluent from the four wastewater treatment plants responsible for treating sanitary waste from almost two million people in the drainage area. This treated effluent is responsible for contributing a large portion of the nitrogen loading into Jamaica Bay.
- Significant alterations to natural features of watershed have resulted from the replacement of natural areas with expanses of impervious surfaces. This reduces the natural attenuation of stormwater and upland pollutants which would normally occur through transpiration, biogeochemical processes and soil storage.
- Hardened shorelines around the perimeter of Jamaica Bay prevent natural inland migration of marshes and the input of upland sediment.

These changes have resulted in water quality changes including aesthetically displeasing periodic algal blooms, depressed dissolved oxygen (DO) levels during the summer months in select areas of the Bay (from nutrient enrichment and poor tidal flushing), and possibly the preclusion of the minimum environmental conditions required for additional ecosystem diversity and recruitment, such as the return of submerged aquatic vegetation (SAV), including eel grass (*Zostera marina)*. However, in spite of these changes, Jamaica Bay remains a vital ecological "powerhouse" that is unrivaled by any other regional natural resource. To help reduce some of the negative attributes of these often irreversible alterations and to help improve the ecological integrity and biodiversity that will lead to more suitable habitat conditions for natural biological regeneration and sustainability, the *Jamaica Bay Watershed Protection Plan* (JBWPP) has identified potential management strategies that focus on: 1) Water Quality, 2) Restoration Ecology, 3) Public Use and Enjoyment, 4) Sound Land Use and Development, 5) Public Education and Outreach and 6) Coordination and Implementation. While this chapter focuses on Water Quality, all the strategies do not operate and cannot be thought of in isolation to one another, but rather synergistically interacting with one another to provide a more sustainable environment.

One of the ways to determine the health of a waterbody is to measure the amount of DO within the water column. Healthy waterbodies typically have dissolved oxygen greater than 5.0 milligrams per liter (mg/l) at all times to support adequate environmental conditions for all developmental stages of aquatic life. Although hypoxia can occur naturally, lower levels of DO can suggest that some type of pollution, altered physical properties and currents, and/or excess nutrients is affecting the ecosystem. Overall, mobile adult aquatic life forms are more tolerant of lower DO levels on a temporary basis, but larval and juvenile stages that are dependent upon tidal circulation for movement are more sensitive to lower DO levels.

Healthy Waters ≥ 5.0 mg/l
Hypoxia (Less than 2.0 mg/l)
Severe Hypoxia (0.2 mg/l – 2.0 mg/l)
Anoxia (0 mg/l - 0.2 mg/l)

To date, much of the focus and research of the NYCDEP, the NYSDEC and others to determine the environmental health of Jamaica Bay has primarily centered on meeting the required DO standards of the Bay and its tributaries. While this is a critical determining factor, the complexity and challenges of meeting the required DO levels in specific highly physically altered geographic regions of the Bay (*i.e.*, Grassy Bay and North Channel) potentially excludes from consideration the improvement to other valuable habitats through the reduction of chlorophyll and dissolved inorganic nitrogen (DIN) levels within select areas of Jamaica Bay. Grassy Bay and North Channel represents a relatively small surface area of the Bay (approximately 12 percent). The remaining 88 percent of the Bay has demonstrated improved ecological health, as demonstrated by increased biological diversity.

Jamaica Bay is classified by the NYSDEC as Class SB saline surface waters. Class SB applies to the open waters of Jamaica Bay, Shellbank Creek, Gerritsen Creek and Mill and East Basins. The remaining tributaries of Jamaica Bay; Shellbank Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin are classified as Class I. The best usages of Class SB waters are primary and secondary contact recreation and fishing. These waters are also suitable for fish propagation and survival. Class I waters are best suited for secondary contact recreation (*i.e.*, boating) and fishing. The current DO standards for SB and I waters are 5.0 mg/l and 4.0 mg/l, respectively. Certain areas of Jamaica Bay such as Grassy Bay, North Channel and the tributaries, do not consistently meet these standards, particularly in the bottom waters and during the summer months.

TABLE 3.1. New York State Water Classifications Best Use

Class	Usage	DO (mg/l)
SA	Shellfishing for market purposes, primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	≥ 5.0
SB	Primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	≥ 5.0
I	Secondary contact recreation fishing. Suitable for fish propagation and survival.	≥ 4.0

The nitrogen loading sources to Jamaica Bay and their respective percentages on an annual basis can be summarized as follows:

- Water Pollution Control Plants (WPCPs) (95%);
- Combined sewer overflows (1.1%);
- Stormwater runoff (1.2%);
- Atmospheric deposition (1.2%); and
- Landfills (1.4%).

Water quality sampling and water quality models have shown that Jamaica Bay is a eutrophic system, a system that contains excess nutrients, typically in the form of nitrogen. However, in spite of this, water quality indicators (*e.g.*, DO) suggest that the water quality of Jamaica Bay remains good, with the exception of seasonally-specific geographic areas, like Grassy Bay and North Channel. The eutrophication that occurs primarily results from the treated wastewater discharge of nearly two million people from four WPCPs and other sources that discharge nitrogen to the Bay. Eutrophication promotes the growth of planktonic algae. The primary macronutrients that are required for algal growth are nitrogen and phosphorus. If either nitrogen or phosphorus concentrations in the water column are low, algal growth becomes nutrient-limited. In most estuarine systems, nitrogen is typically the limiting nutrient, which means that algae typically deplete nitrogen in the water column before they deplete phosphorus. However, within Jamaica Bay, nitrogen and phosphorus are in excess and, before these can be depleted, light required for chlorophyll production becomes the limiting growth factor from high turbidity levels that reduce light transmission through the water. These excess nutrients lead to increased algal blooms that increase biological oxygen demand (BOD), reduce the DO levels, lower ecological function in limited areas, and have the potential to decrease aesthetic qualities of Jamaica Bay.

The Comprehensive Jamaica Bay Water Quality Plan (CJBWQP) demonstrated that current water quality standards for DO could not be fully attained even with the relocation of all WPCP discharges to the ocean. The primary reasons for this are the altered bathymetry of the Bay that results in changes to circulation patterns and stratification issues in the deeper portions of the Bay. Even with the relocation of all WPCP discharges, the baywide and Grassy Bay annual average for percent attainment with water quality standards is approximately 99.7% and 98.8%, respectively.

Currently, the Bay receives approximately 40,100 lb of nitrogen per day (12-month rolling average through July 2007) but is roughly estimated to only be capable of naturally assimilating approximately up to 20,000 lb of nitrogen per day. The location of the treatment plant effluent in proximity to the DO hot spots also seems to be an important consideration and, therefore, it is prudent to target nitrogen reductions at particular treatment plants (26^{th} Ward and Jamaica WPCPs) rather than apply a uniform nitrogen reduction at all four treatment plants. The reduction of nitrogen can be expected to reduce the intensity and duration of algal blooms that result in poor water quality and reduce the overall negative qualities sometimes experienced on the Bay. Lower levels of nitrogen may also provide the potential to reintroduce important and extirpated habitats such as eel grass beds, to limited areas of Jamaica Bay. In addition to the habitat improvements, the reintroduction of eel grass would provide additional nitrogen reduction through plant uptake. Potential areas suitable for eel grass are primarily in the western and southeastern sections of the Bay where chlorophyll (a measure of nutrient enrichment) levels are lower than the eastern and northeast sections of the Bay. The water quality models suggest that additional nitrogen reductions will bring chlorophyll levels closer to the environmental conditions that permit their re-introduction.

The appropriate approach to evaluating and developing potential solutions requires a proactive position that is technically informed and is based in sound scientific principles and study. The understanding of these scientific principles and studies provides a better framework in the development of potential measures that can improve ecological productivity, minimize environmental damage and improve water quality.

While eutrophication and nutrient loadings into the Bay are key factors that impair water quality, they are not the only factors. The changes to water quality that have occurred within the Bay and its tributaries are the result of many significant alterations, including bathymetry changes, introduced WPCP and CSO discharges, hardened shorelines, and a near complete replacement of natural attenuating features within the watershed to impervious urban features and structures that significantly reduce precipitation infiltration, natural cleansing abilities and substantially increases stormwater runoff. These changes have resulted in increased nutrient loading, and altered tidal flushing patterns that would otherwise help "cleanse" the Bay of these additional loadings. The enormity and permanent nature of many of these changes makes it difficult, if not impossible to remedy the situation and certainly not always in an expeditious manner.

To advance these goals and to further improve upon existing efforts, the JBWPP has developed a number of management strategies to address the following water quality objectives:

- Objective 1A: Reduce Nitrogen Loading to the Tributary Basins and Jamaica Bay;
- Objective 1B: Reduce Combined Sewer Overflow (CSO) Loadings into Tributary Basin to Improve Pathogen and DO Levels;
- Objective 1C: Increase Dissolved Oxygen Levels in Tributary Basin Areas of Chronic Hypoxia;
- Objective 1D: Reduce Flooding Throughout the Jamaica Bay Watershed; and
- Objective 1E: Develop a Robust Scientific Monitoring Program.

The Objectives and Management Strategies discussed in this Chapter utilize sound environmental engineering construction methods, environmentally friendly and ecologically sustainable practices, and innovative techniques that will assist in reducing nitrogen loading and improving aquatic and wildlife habitats. Other strategies focus on reducing the potential for CSO events, reducing pathogen loading and improving DO levels within the tributaries. These strategies include infrastructure upgrades, cleaning sewers, and dredging within CSO tributaries to remove accumulated sediment. These efforts will not only improve water quality, but will also restore a higher quality benthic habitat. These practices are consistent with standard ecological watershed planning principles and are in agreement with many of PLANYC 2030 Water Quality Initiatives for a greener, greater New York.

OBJECTIVE 1A: REDUCE NITROGEN LOADING TO THE TRIBUTARY BASINS AND JAMAICA BAY

Current Programs

Since the early 1990s, NYCDEP has implemented a number of programs to reduce nitrogen loading and improve DO conditions within Jamaica Bay. These programs include:

- Retrofit BNR enhancements at the 26th Ward WPCP, including the addition of baffles, mixers, and froth control hoods to the aeration basins;
- Optimizing the treatment of centrate in separate aerator tanks to reduce nitrogen discharges;
- Best efforts to minimize the importation of sludge from locations outside of Jamaica Bay; and
- Ongoing Jamaica WPCP improvements.

To date, these efforts have reduced nitrogen loadings to the Bay by approximately 25 percent, with further improvements anticipated upon the completion of current upgrades and planned upgrades at the 26th Ward, and Jamaica WPCPs.

The Management Strategies below discuss additional proposals to reduce nitrogen loads to Jamaica Bay not included in previous planning efforts.

Management Strategy 1a1: Carbon addition facilities at 26th Ward and Jamaica Water Pollution Control Plants.

STRATEGY DESCRIPTION

Jamaica Bay is not alone in facing water quality issues that affect its ecological health and productivity. The Long Island Sound Study led to an agreement by the stakeholders to reduce the overall nitrogen discharges to Long Island Sound 58.5 percent from the baseline load of 106,807 pounds per day by the year 2017. The agreement establishes interim 5 and 10 year targets to measure progress. As of July 2007, the reduction of nitrogen discharges into Long Island Sound had decreased 21 percent from the high discharges of the early 1990s.

As shown in Figure 3.1 below, the reduction in total nitrogen (TN) to Jamaica Bay over a similar time period as a result of NYCDEP efforts has shown a reduction of nitrogen of 25%. The NYCDEP is currently in negotiations with the NYSDEC regarding the CJBWQP. The plan had proposed a Level II - Step Feed Biological Nutrient Removal (BNR) upgrade at both 26th Ward and Jamaica WPCPs, along with recommending some type of bathymetric restoration of the Bay that includes the efforts of all stakeholders. Based on ongoing discussions with the NYSDEC, the proposed CJBWQP will most likely be modified. The new approach will include establishing equivalency factors for all four WPCPs to help quantify specific nitrogen reduction goals for each WPCP and additional cost effective nitrogen removal alternatives including supplemental carbon addition. Jamaica Bay has its own unique issues that need to be incorporated into the final approved plan.

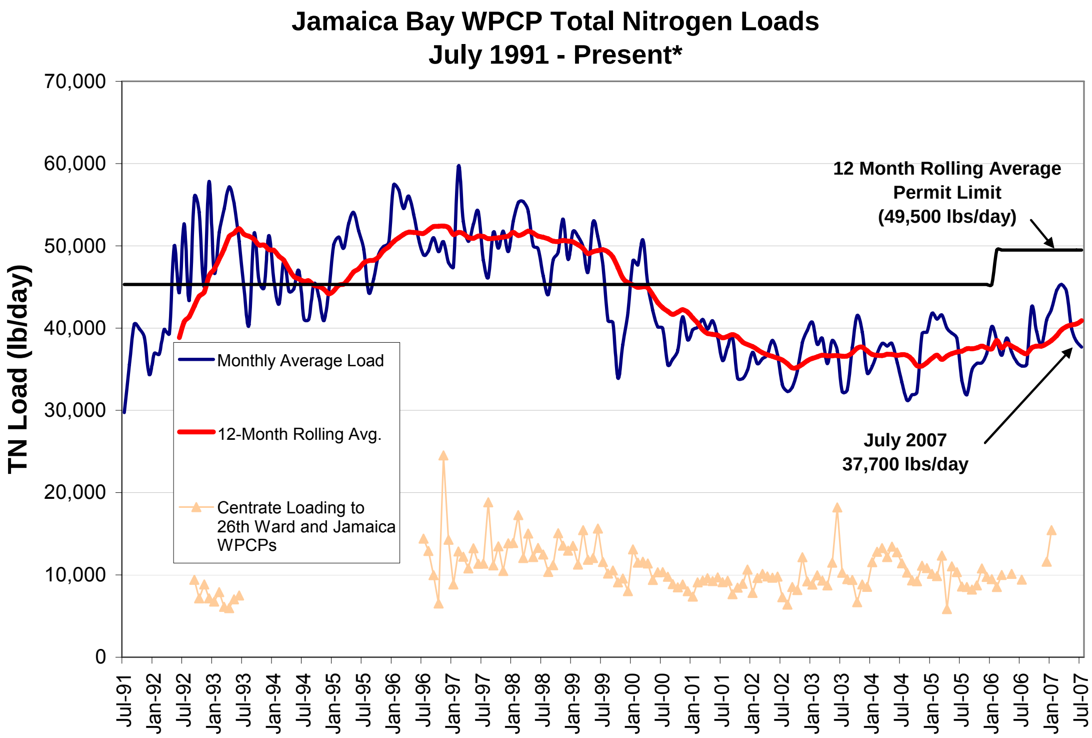


FIGURE 3.1 Summary of Jamaica Bay Nitrogen Discharges from July 1991 to July 2007
Source: NYCDEP

Prior to the finalization of these negotiations, NYCDEP is determining the feasibility of an interim supplemental carbon system at the 26th Ward WPCP that could be implemented fairly quickly in conjunction with dewatering the Jamaica WPCP sludge at the plant on a regular basis to take advantage of the existing separate centrate treatment process and interim supplemental carbon addition system.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Over the last 10 years, NYCDEP has significantly reduced nitrogen loading to Jamaica Bay, from a high of approximately 53,000 lb/day in 1996 to an average of 40,100 lb/day today. While this represents a substantial reduction in nitrogen of nearly 25 percent, it is not within the estimated natural assimilative capacity of the Bay, as evidenced by the fact that areas of the Bay still experience hypoxia and elevated concentrations of algae.

This significant reduction has improved environmental improvements within Jamaica Bay. However, water quality models seem to indicate that the further lowering of nitrogen does not necessarily provide additional substantial water quality benefits for leading water quality indicators such as DO levels.

While DO is a major focus of NYCDEP's planning efforts, this *Jamaica Bay Watershed Protection Plan* takes a broader approach in its consideration of ecosystem restoration objectives. Additional nitrogen reductions can be a precursor to the recovery and restoration of additional habitats, such as the Eastern oyster and *Zostera mariana* (eel grass) beds and can potentially slow the observed accelerating loss of salt marsh.

Based on a comparison of model output for 1) permit conditions (Baseline), 2) 2006 current conditions, and 3) 2006 current conditions with carbon addition and upgrades at Jamaica and 26th Ward WPCPs, additional nitrogen reduction appears to do little for improving DO levels.

The four NYCDEP WPCPs that discharge into Jamaica Bay currently have a 12-month rolling average TN interim permit limit of 49,500 lb TN/day to allow for construction upgrades at the 26th

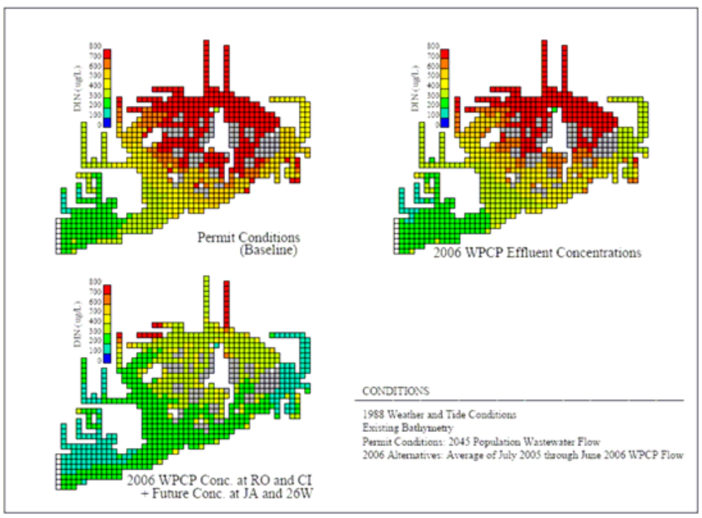


FIGURE 3.2 Baseline, Existing and Future Concentrations, Summer Average DIN (ug/L); Source HydroQual

Ward WPCP. Following completion of Contract 12 improvements to the 26th Ward WPCP, the 12-month rolling average TN permit limit will be reduced to 45,300 lb TN/day. Under current conditions, the four WPCPs discharge approximately 36,000 to 40,100 lb TN/day on an annual basis. From June 2001 through July 2007, the average TN load from the four Jamaica Bay WPCPs was approximately 37,300 lb TN/day.

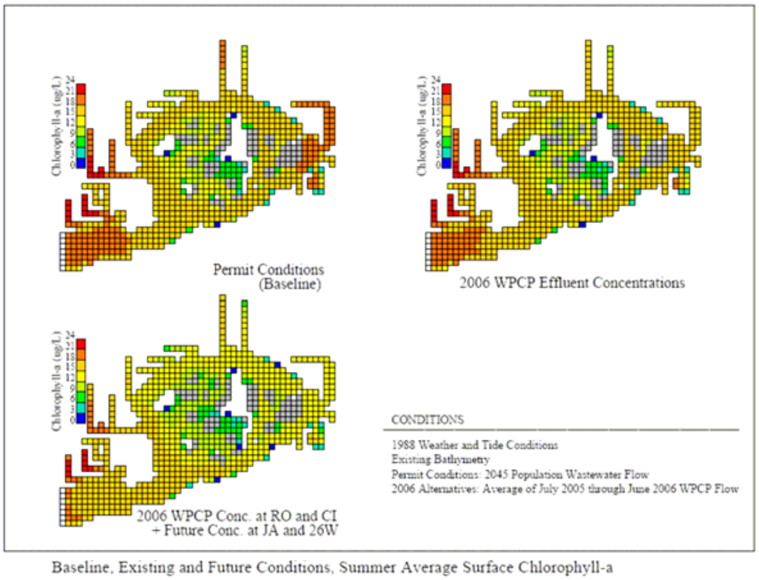


FIGURE 3.3 Baseline, Existing and Future Conditions, Summer Average Surface Chlorophyll-a; Source: HydroQual

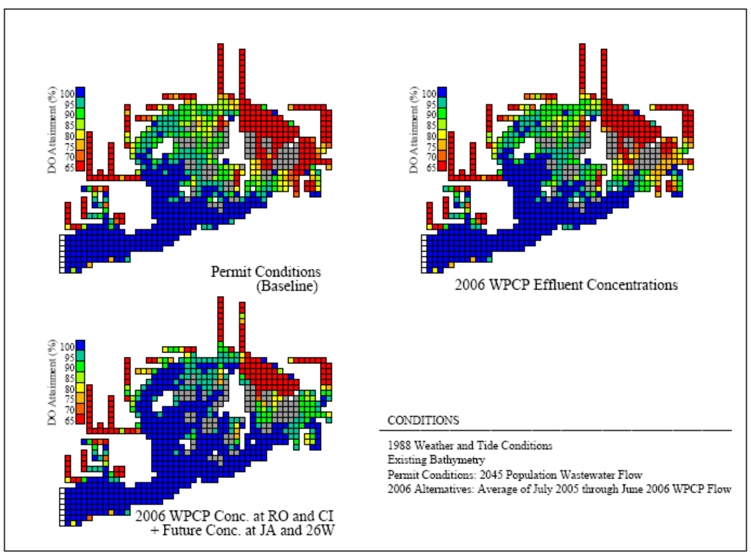


FIGURE 3.4 Baseline, Existing and Future Concentrations, Summer DO Attainment; Source: HydroQual

Table 3.2 summarizes the expected nitrogen effluent discharges from various BNR treatment alternatives. Current negotiations with the NYSDEC evaluate the different permutations of the original alternatives to determine the most cost-effective means of both reducing nitrogen to Jamaica Bay and improving dissolved oxygen and the ecosystem. One alternative currently being investigated includes incorporating carbon addition with Level II BNR at the Jamaica and 26th Ward WPCPs along with other process enhancements including optimization of the dewatering operations.

TABLE 3.2 Projected Nitrogen Concentration For Treatment Alternatives		
Scenario	**Projected TN Discharge**	**Approximate Percent Reduction from Baseline**
Baseline (1996)	17 mg/l – 26 mg/l	
Low Level Step Feed BNR	12 mg/l – 16 mg/l	34%
Mid Level Step Feed BNR	9 mg/l – 13 mg/l	48%
High Level Step Feed BNR	5 mg/l – 9 mg/l	68%
Note: Reductions in discharge are from CY 1996 and permutations of minor optimization to Mid Level Step Feed BNR with supplemental carbon addition suggest that effluent discharges similar to that of High Level Step Feed BNR may be achieved at a lower cost.		

The Jamaica Bay Eutrophication Model (JEM) was used in this analysis to assess the water quality benefits predicted from the proposal to add carbon (methanol) to the WPCP nitrogen removal process. For this scenario, the water quality model was set-up for a baseline scenario that included the following:

- 2045 WPCP flows;
- 1988 rainfall data;
- Contract 12 Upgrades at 26th Ward WPCP, Low Level Step Feed BNR at Jamaica WPCP;
- Current Grassy Bay bathymetry to remain and not be filled; and
- Paerdegat CSO retention facility operational.

Based on Jamaica Eutrophication Model (JEM) modeling, carbon addition is predicted to result in only a small improvement in attainment of the DO standard. However, this reduction is the precursor to reducing chlorophyll and DIN to levels that would reduce algal blooms, improve aesthetic qualities and increases the potential for more diverse habitats (*e.g.*, eel grass and oysters) to be restored in limited areas of the Bay. Attainment of the DO standard in Grassy Bay during the summer increases from 47.8 to 48.2 percent based on model results with this additional amount of TN removal.

The following tables present a comparison of model output for permit conditions, the 2006 current conditions and for the 2006 current conditions with upgrades at the Jamaica and 26th Ward WPCPs plus carbon addition at these two plants. Table 3.3A shows that on an annual average basis, the DO concentration declines slightly in the North Channel near Hendrix Creek, near the Marine Parkway Bridge adjacent to Rockaway, and near Beach Channel adjacent to Rockaway, while it increases slightly in Grassy Bay. This decline is associated with a small reduction in the phytoplankton biomass as is noted by the calculated reduction in chlorophyll concentrations. Most of the lower DO concentrations calculated by the model for the carbon addition scenario occur during the colder months when the DO concentration is well above the standard. The minimum DO concentration in these locations does increase, with the exception of minor decrease near the Marine Parkway Bridge. The minimum DO concentration in Grassy Bay increases significantly from the permit condition to the proposed plan.

The results in Table 3.3B show that carbon addition is more effective in reducing the water column nitrogen concentrations in these two locations. Summer TN is reduced by approximately 50 percent at one location (Beach Channel) and summer DIN is reduced by approximately 47 percent at another location (Grassy Bay) with the upgrades to the WPCPs and the additional of carbon to the treatment process. This results in a small (approximately 6-14 percent) reduction in the chlorophyll concentrations. Table 3.3C shows an even greater reduction in DIN and chlorophyll in the far eastern sections of the Bay (Thurston Basin and Head of Bay) where summer DIN is reduced by as much as 67 percent and summer chlorophyll is reduced by 15 to 20 percent.

TABLE 3.3A. Relative Change In Water Quality Parameters Due To Carbon Addition

		Outside Hendrix Creek			Grassy Bay		
		Baseline Condition	Baseline Condition + Carbon Addition	Percent Change	Baseline Condition	Baseline Condition + Carbon Addition	Percent Change
Annual Statistics	Average Bottom DO (mg/L)	9.92	9.88	-0.42	8.42	8.85	5.16
	Minimum Bottom DO (mg/L)	4.48	4.81	7.37	1.01	1.72	70.30
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	--	0.81		--	-1.07	
	Average Water Column DIN (mg/L)	0.49	0.27	-45.97	0.93	0.32	-65.67
	Average Water Column TN (mg/L)	1.80	1.21	-32.66	2.58	1.36	-47.28
	Average Water Column Chlorophyll-a (ug/L)	29.18	26.16	-10.34	31.71	27.93	-11.91
Weekly Average for week w/ highest Water Column Chl. a conc. in Grassy Bay (Day 71)	DIN (mg/L)	0.14	0.08	-41.91	0.53	0.09	-82.88
	TN (mg/L)	1.62	1.05	-35.08	2.46	1.28	-47.97
	Chlorophyll-a (ug/L)	58.45	41.94	-28.25	62.16	50.62	-18.56
	DO (mg/L)	12.19	12.82	5.21	11.35	13.54	19.35

TABLE 3.3B. Relative Change In Water Quality Parameters Due To Carbon Addition		Marine Parkway Bridge (near Rockaway)			Beach Channel (near Rockaway)		
		Baseline Condition	**Baseline Condition + Carbon Addition**	**Percent Change**	**Baseline Condition**	**Baseline Condition + Carbon Addition**	**Percent Change**
Annual Statistics	Average Bottom DO (mg/L)	9.42	9.38	-0.38	10.14	10.06	-0.76
	Minimum Bottom DO (mg/L)	6.06	6.03	-0.50	5.30	5.83	10.00
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	--	-0.32		--	-090	
	Average Water Column DIN (mg/L)	0.32	0.26	-16.94	0.37	0.18	-50.20
	Average Water Column TN (mg/L)	1.22	1.05	-14.30	1.67	1.12	-33.15
	Average Water Column Chlorophyll-a (ug/L)	22.96	21.56	-6.06	29.27	25.05	-14.41
Weekly Average for week w/ highest Water Column Chl-a conc. in Beach Channel (Day 115)	DIN (mg/L)	0.15	0.16	0.32	0.08	0.04	-49.07
	TN (mg/L)	1.21	1.06	-12.40	1.56	1.03	-34.14
	Chlorophyll-a (ug/L)	48.52	44.30	-8.71	56.85	43.09	-24.21
	DO (mg/L)	12.01	11.82	-1.62	12.10	11.41	-5.73

TABLE 3.3C. Relative Change In Water Quality Parameters Due To Carbon Addition

		Far Rockaway (East of JFK Airport)			Head of Bay		
		Baseline Condition	Baseline Condition + Carbon Addition	Percent Change	Baseline Condition	Baseline Condition + Carbon Addition	Percent Change
Annual Statistics	Average Bottom DO (mg/L)	9.53	9.35	-1.95	9.27	9.06	-2.26
	Minimum Bottom DO (mg/L)	2.83	3.79	33.92	2.22	3.13	40.99
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	-	-1.32		-	-1.52	
	Average Water Column DIN (mg/L)	0.27	0.11	-58.73	0.22	0.10	-56.82
	Average Water Column TN (mg/L)	1.69	1.04	-38.55	1.62	1.01	-37.70
	Average Water Column Chlorophyll-a (ug/L)	29.57	22.05	-25.41	29.42	21.14	-28.14
Weekly Average for week w/ highest Water Column Chl-a conc. in Beach Channel (Day 115)	DIN (mg/L)	0.09	0.07	-23.25	0.07	0.03	-58.19
	TN (mg/L)	1.60	1.08	-32.61	1.55	1.04	-33.18
	Chlorophyll-a (ug/L)	48.96	35.88	-26.73	46.81	35.89	-23.33
	DO (mg/L)	9.76	14.36	47.16	9.51	14.40	51.44

An additional analysis was conducted to determine whether carbon addition at all four Jamaica Bay WPCPs would provide additional water quality benefits. The results of this analysis not shown herein indicate there is little if any noticeable change in the model calculations as a result of the addition of carbon at the Coney Island and Rockaway WPCPs. The NYCDEP is in the process of developing "trading ratios" demonstrating the relative impact per pound of nitrogen discharge has on the attainment of water quality standards from each of the four WPCPs in the Bay.

These and other measures, such as improved stormwater management through on-site and off-site Best Management Practices and an increase of vegetation as a result of efforts under PLANYC 2030 to plant 1 million trees throughout the City over the next 20 years, have the potential to provide cumulative environmental improvements that may not be perceptible with current modeling efforts.

Positive environmental effects that are currently not easily assessed may result from the synergy of many small important interacting improvements.

Technical

There are few technical issues associated with carbon addition. It is a proven technology that is also proposed for use at other NYCDEP WPCPs. Carbon addition involves construction of relatively small facilities which contain liquid storage system and feed systems. Methanol and/or ethanol are flammable and precautionary measures will be taken during operations. The market for supplemental carbon is volatile and is expected that alternate supplemental carbon sources will be identified and utilized as market conditions dictate.

Legal

NYCDEP currently has State Pollutant Discharge Elimination System (SPDES) permits that define the requirements relative to the minimum effluent limits for the WPCPs discharging wastewater into Jamaica Bay. Further, NYCDEP and NYSDEC have a Nitrogen Consent Order that further specifies City requirements related to effluent nitrogen from WPCPs. One requirement of this Consent Order was the mandate that NYCDEP develop a plan for improving DO levels within Jamaica Bay as they are impacted by the discharge of nitrogen. The CJBWQP was a requirement of the Consent Order. NYCDEP and NYSDEC are currently in discussions on the recommendations proposed in the CJBWQP. NYCDEP may modify the recommendations in the CJBWQP as negotiations advance.

Cost

See *Implementation Strategies* below.

RECOMMENDATION

As part of the negotiation process with NYSDEC, NYCDEP will propose carbon addition at the 26th Ward and Jamaica WPCPs as a potential strategy for further reducing nitrogen loadings to Jamaica Bay. This recommendation is subject to ongoing discussions and negotiation with NYSDEC with respect to the final approved CJBWQP. See also *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Carbon Addition Facilities at 26th Ward and Jamaica WPCPs

As discussed above, NYCDEP will propose carbon addition at 26th Ward and Jamaica WPCPs as potential strategies to reduce nitrogen loadings as part of ongoing discussions on the CJBWQP with NYSDEC.

Schedule: To be determined based on negotiations with NYSDEC.

Cost: The incremental costs for the construction and maintenance of carbon addition facilities at the 26th Ward and Jamaica WPCPs beyond that of the existing upgrades will be developed pending negotiations with NYSDEC.

Interim Carbon Addition Facilities at 26th Ward WPCP and Reroute Jamaica WPCP Centrate Processing to 26th Ward WPCP

To implement additional nitrogen reductions in the near term, temporary carbon addition will be put in place in several aeration tanks at the 26th WPCP. Once these changes are put in place, NYCDEP will consider rerouting Jamaica WPCP centrate processing to 26th Ward WPCP to maximize the effects from the temporary carbon addition.

Schedule: To be determined, but not less than 36 to 40 months.

Cost: To be determined.

Management Strategy 1a2: Evaluate and implement alternative technologies.

STRATEGY DESCRIPTION

Algae and Sea Lettuce Harvesting

This strategy is to evaluate the potential for harvesting excess algae and sea lettuce (*Ulva lactuca*) as a limited means to reduce nitrogen, improve aesthetic qualities, and produce biofuel and byproducts (glycerol) as a potential carbon source for BNR operations. This strategy is limited to those temporal and spatial events (*e.g.,* lowest low tides and weather conditions) that enable the maximum amount of harvesting to occur from the surface without impacting existing marine organisms. The strategy will not harvest Ulva from below the surface or on the bottom of Jamaica Bay to prevent disturbance to benthic organisms. Additional information regarding these unique conditions is required before moving forward to determine the feasibility. Jamaica Bay currently experiences algae blooms on average approximately two times a year, from February through April and again in mid-August through September. The decomposition of the algae increases the BOD, lowers the DO of the water column, and creates stress for aquatic organisms.

Under favorable environmental conditions, algae can grow very rapidly. While a number of sources of bio-feedstock are currently being examined for biofuel production, algae have emerged as a promising source that requires greatly reduced energy inputs to produce when compared to agriculturally derived feedstock sources (Haag, 2007).

Sea lettuce and other types of algae grow in salt or brackish waters, particularly in those that are nutrient-rich or polluted. Nutrients enter Jamaica Bay from several sources including point sources (end-of-pipe discharges coming from municipal and industrial wastewater treatment plants), nonpoint sources (runoff), and atmospheric deposition (exhaust and emissions). When areas become overgrown with algae, DO is reduced as the algae begin to decompose and settle to the bottom of the water column.

NYCDEP is investigating the potential use of existing skimmer vessels for the purposes of piloting this strategy.

Algal Turf Scrubbers

Algal Turf Scrubbers® (ATS) are a unique wastewater treatment technology that cultures diverse, natural assemblages of benthic organisms, bacteria, and phytoplankton on an inclined flow-way and screen substrate to remove a variety of nutrients or contaminants from polluted waters (Adey *et al*., 1993; Adey *et al*., 1996). The first algal scrubbers were patterned after marine algal mats found on the surfaces of coral reefs. Later versions of ATS were found to be readily adapted to estuarine and freshwater sources with algae native to those ecosystems. The ATS process is a patented water treatment technology developed by Dr. Walter Adey and is held by the Smithsonian Institution.

For large scale applications, ATS mimics a constructed artificial stream ecosystem designed to promote algal growth as the pollutant uptake and removal mechanism which is driven by high rates of photosynthesis (Craggs *et al*., 1996). Long, slightly sloped, shallow raceways of impermeable material are stretched across the ground surface or a raised support frame and dosed with effluent in regular pulses. The use of natural sunlight is the norm for these systems and, as the seasonal photoperiod changes, so does algal productivity. Smaller systems utilize very high output lights and greenhouse structures to maintain high algal productivity and pollutant removal efficiency during non-summer seasons.

Periodic harvesting of the algal turf removes nutrients and pollutants from the system while stimulating continued algal growth and dramatically increasing algal uptake efficiencies (Adey and Loveland 1991). There is practical interest in the use of the harvested algae as fertilizer (Mulbry *et al*., 2005), a high protein feed stock for animals (Pizarro *et al*., 2006), or as a source for biodiesel production (Briggs, 2004). An additional by-product of the ATS is glycerol, which has the potential to be used an alternative carbon source at the 26th Ward and Jamaica WPCPs. A current pilot study by NYCDEP, the PO 55 Pilot Study, is evaluating alternative sources (other than methanol and ethanol) to be used as a carbon source for additional nitrogen reduction. Initial results of this study indicate that glycerol has a high potential as an alternative carbon source. The additional use of the algae as a beneficial by-product makes the treatment of wastewater with ATS potentially very cost-effective.

The ATS eco-technology has been employed for marine coral mesocosm research, groundwater contaminant removal, dairy manure waste treatment, agricultural run-off phosphorus removal, aquaculture wastewater, and municipal wastewater treatment (Adey and Hackney, 1989; Adey and Loveland, 1991; Adey *et al*., 1993; Adey *et al*., 1996). The application of these systems for the removal of water-based pollutant loads is broad, but is limited by the space required for very large hydraulic loading rates. Typically for larger hydraulic loads, such as with municipal wastewater treatment plants, only a percentage of the WPCPs total load is diverted to the ATS system to achieve a greater degree of treatment. A small percentage of the final effluent volume could be treated with ATS to provide additional nitrogen reductions beyond that expected with the implementation of carbon addition facilities at the 26th Ward and Jamaica WPCPs and provide valuable sustainable by-products.

TABLE 3.4 Algal Turf Scrubber Maximum Nitrogen Removal Efficiencies

Reference	Effluent Type	Maximum N Removal *
Craggs *et al*., 1996	Municipal Secondary Treated	1110 mg/m^2/day
Blankenship, 1997	Municipal Secondary Treated	2886 mg/m^2/day
Mulbry and Wilkie, 2001	Dairy Manure	350 mg/m^2/day
Kebede-Westhead *et al*., 2003	Dairy Manure	1330 mg/m^2/day
Pizarro *et al*., 2002	Dairy Manure	5700 mg/m^2/day

** Removal rates for water treatment systems that require area as a key component of their treatment process are commonly expressed as mg/m^2/day*

Of the above applications, municipal secondary wastewater treatment has been applied in at least two instances, one in central California and one on Maryland's eastern shore. The Maryland ATS system was implemented at a wastewater treatment plant in Fruitland, diverting 15% of the treatment plant's 500,000 gallons per day (GPD) discharge (75,000 GPD) down 10 parallel, 100 yard raceways. Inorganic nitrogen content entering the ATS was approximately 20 mg/L, with reductions reported to approximately 3-4 mg/L (Blankenship, 1997). Unfortunately, there has been little published scientific data related to its operational efficiencies. For this reason, the Patterson, California ATS system (described below) TN uptake rates are used for analyzing the potential for application at select Jamaica Bay WPCPs, given current space constraints.

The benefits and challenges of using ATS can be summarized as follows:

- Nitrogen and phosphorus uptake are driven by high rates of photosynthesis and could provide additional limited "polishing" of treated wastewater;
- Using ATS requires 3 to 5% of the land area of comparable treatment wetlands;
- Using ATS is less effective during colder months; and
- Harvested algae could be processed to produce limited quantities of biofuel.

Oyster Restoration

Oysters are known as a keystone species and an "ecosystem engineer" that has the ability to modify it environs through its life processes. A keystone species is one whose impact on its community or ecosystem is disproportionately large relative to its abundance (Paine, 1996). The oyster plays an important role in stabilizing and maintaining other species diversity within systems that support sufficient densities. They are such an important piece of the ecological puzzle that when they are removed from the environment, structures and functions of the ecosystem can become unstable, affecting overall ecological health. They serve as important filter feeders, were an important historical commercial fishery, and provide important habitat for many other commercially important species. In 1609 oyster reef habitat was so abundant (approximately 350 square miles of oyster reef habitat) within New York's coastal waterways that they often presented navigation hazards to shipping (Gaia, 2007). In addition, it is believed that 18 trillion gallons of water within Chesapeake Bay were once filtered every 3 or 4 days; this now takes approximately 1 year for the same filtering (Chesapeake Bay Foundation, 2007). The approximately 80 billion gallons of water within Jamaica Bay could have been filtered within the same time frame with the aid of oyster reef habitat. The water within Jamaica Bay could be filtered providing some treatment with the aid of oyster reef habitat.

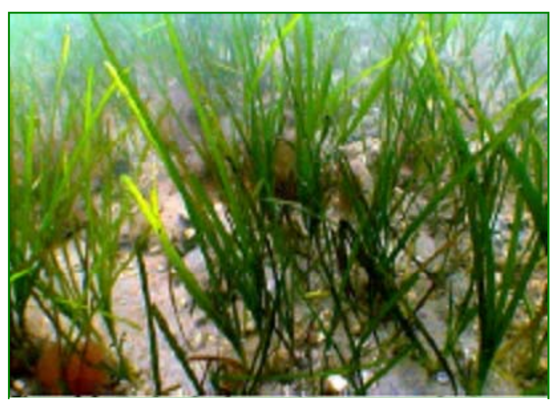
Oyster (*Crassostrea virginica*)
Source: Maryland Sea Grant

By providing clearer water (*e.g.,* fewer algae blooms) oyster reef restoration increases the potential for the successful re-introduction of the extirpated submerged aquatic vegetation eel grass (*Zostera mariana*), which is light dependent. Current water turbidity in the eastern sections of the Bay and the "head" end of all the tributaries prohibit eel grass systems and, to some degree, suppress oyster habitats from becoming a fully functional and valuable component of the Jamaica Bay ecosystem. However, western sections of Jamaica Bay and the "mouth" of several of the tributaries already satisfy oyster requirements and, with improvements in nitrogen reduction from the expected enhanced nitrogen removal at the 26th Ward and Jamaica WPCPs, these areas will be closer to meeting the requisite environmental conditions capable of supporting eel grass. The natural filtering capabilities of oysters can help remove nitrogen and suspended sediments from the water column within an eel grass bed and may provide sufficient environmental conditions to support eel grass. A single mature oyster can filter approximately 2.5 gallons per hour or 35 gallons per day and can remove, through sediment sequestration of pseudo feces, approximately 20% of the nitrogen it takes in (South Carolina Oyster Restoration and Enhancement, 2007). Although they do not occupy the same ecological niche, they are spatially related to one another and eel grass and oyster restorations are beginning to become linked to take advantage of the filtering benefits of oysters. See Tables 3.5 and 3.6 for details regarding habitat requirements of oysters and eel grass, respectively.

Ribbed Mussels

Ribbed mussels are commonly found growing around the perimeter of Smooth Cordgrass (*Spartina alterniflora*), mudflats and other suitable marine substrate. In addition to their habitat value, they provide important wetland soil erosion control by forming dense mats that reduce wave energies and permit the potential build up of sediments. They are found in most parts of Jamaica Bay, in varying densities. "Like the Eastern oyster, ribbed mussels (in enough numbers) can filter high volumes of water in the tidal marshes during each cycle, are crucial to the cycling of energy and nutrients and are an important prey species of birds and the blue crab" (Chesapeake Bay Program, 2004).

Analogous to the approach of using oysters to filter additional nitrogen from the water, there is also interest in using ribbed mussels (*Geukensia demissa*) to improve water quality within the CSO tributaries of Jamaica Bay. In addition to their nitrogen removal characteristics, ribbed mussels have also been identified to be potentially efficient in sequestering pathogens from the environment (Gaia 2007). While pathogen levels are not an issue within the open waters of Jamaica Bay, periodic CSO events do negatively impact the affected CSO tributaries. A high density of ribbed mussels may help reduce pathogen levels within these select tributaries and improve water quality. However, the level of performance of the ribbed mussels and the density required to reduce pathogens will need to be tested through a pilot study.



Beds of eel grass (*Zostera mariana*),
Source: Hudson River Foundation

TABLE 3.5. Summary Of Key Environmental Requirements For The Eastern Oyster Adapted From The Hudson River Foundation "Target Ecosystem Characteristics For The Hudson Raritan Estuary" (Shumway, *et al.* 1996)

Parameter	Description
Habitat and Setting	
Depth	0.6 – 5.0 m
Suspended Particles	Larvae prefer food particles of between 20-30 um and adults can effectively use particles >3 um, but particle composition is important; suspended sediments at about the 0.5 g/L + concentration can kill eggs and larvae (Kennedy, 1991); larvae and adults can vary their ingestion rate to respond to particle volume concentrations between 2 and 100 x 10^5 um^3 (Kennedy *et al*.,1996)
Temperature	Larvae: optimum ~20.0-32.5 C (Calabrese and Daives, 1970); adults: 2.0-36 C
Salinity	Larvae: 10-27.5 ppt (17.5 ppt optimum in LIS; Calabrese and Davis, 1970) adults: 5 to 40 ppt
Dissolved oxygen	20-100% saturation; larvae avoid hypoxia by swimming to surface but adults can survive several days at <1.0 mg/l (Kennedy, 1991)
pH	Larvae prefer between 6.75-8.75 (Calabrese and Davis, 1970)
Substrate	Exposed and clean oyster, other shell or hard surface
Circulation	No ideal rates found, but enough to provide food and remove wastes and to keep larvae in the vicinity of the parent reef (Lenihan, 1999)
Retention and sources	Spatially and temporally interlinked larval source and set opportunities for reef persistence and expansion
Sediment stability	Hard enough so that oyster growth rate can overcome any submersion
Sediment deposition	Neutral sediment balance on reef
Toxic chemicals	Concentrations below health and reproductive impairment (see Kennedy, 1991; Kennedy *et al*., 1996)
Disease and parasites	MSX and DERMO (to a lesser extent) mortality rates can be partially controlled by focusing on lower salinity (~< 12 ppt) and temperature (~<20˚ C) areas and the use of MSX resistant oyster larvae/seed stock (S. Ford, Haskins Shellfish Lab., Bivalve, NJ; Pers. Comm., 2005)
Population Properties	
Critical Oyster Densities	A minimum number of oysters per hectare for successful reproduction and to overcome competition with sessile benthos are known to be important but current research and data do not support a specific value
Connectivity among reefs	Larval dynamics considered across spatially interlinked reef clusters or complexes to sustain estuary scale recruitment

TABLE 3.6. Summary Of Key Environmental Preferences Of Eel Grass (*Zostera mariana*) Summarized From Kemp *et al.* (2004) And Moore (in press) Adapted From The Hudson River Foundation "Target Ecosystem Characteristics For The Hudson Raritan Estuary"

Parameter	Value
Water Movement	Minimum velocity 3-16 (cm^{s-1})(and maximum 50-180 (cm^{s-1})
Hydrodynamics of erosion and accretion	Regime that is closely balanced
Wave Tolerance	<2 m in height for growth and meadow formation
Depth Transmission	Subtidal, typically to 2 meters, minimum of required light through water column is >22% of light
Light	Minimum requirement >15% light at leaf
Total Suspended Solids	<15 m/1
Plankton Chlorophyll a Levels	<15 ug/l
Dissolved Inorganic Nitrogen	<0.15 mg/l
Dissolved Inorganic Phosphorus	<0.01 mg/l
Dissolved Oxygen	>2 mg/l at bottom
Sediments	Grain size, 0.4-72% silts and clays and organic matter
Pore water Sulfide	Healthy Plants, < 1 mm Reduced Growth, >1 mm Death, >2 mm
Temperature	5-30° C with optimum growth and germination range of 10 – 15° C
Salinity	Avoids brackish water, optimum salinity range 10 – 39 psu

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Algae and Sea Lettuce Harvesting
Areas within Jamaica Bay, Grassy Bay and Bergen Basin typically experience the highest chlorophyll levels and corresponding algal growth. For 2003, Grassy Bay had a summer chlorophyll mean of 50.9+/-9.7 ug/L and a peak monthly mean in August of 84.9+/-48.3 ug/L, indicating a fairly sustained period of intense algal blooms. In Bergen Basin, summer chlorophyll means reached 61.9+/-11.1 ug/L and peaked in August at 96.1+/-19.8 ug/L.

Based on existing literature values (Haag, 2007), the harvesting of algae during widespread blooms in Jamaica Bay has the potential for limited nitrogen removal from the Bay (algae is 1% to 6% nitrogen by dry weight), but may have other potential positive environmental benefits: reducing negative aesthetic issues and providing potential alternative energy sources from biofuel production.

Algal Turf Scrubbers®
Application of ATS ecologically engineered technology at the 26th Ward and Jamaica Bay WPCPs may achieve effective degrees of water quality improvements. An initial feasibility analysis at each facility follows.

The model for this analysis is an ATS system constructed in Patterson, California for the treatment of a portion of the municipality's secondary treated waste stream. The City of Patterson is situated in the Central Valley of California approximately 70 miles southeast of San Francisco. The treatment train at the Patterson wastewater treatment facility has a mean hydraulic loading of approximately 800,000 GPD (3028 cubic meters/ day). The flow-way for the system is 500 ft (152.4 m) long and 22 ft (6.7 m) wide with a total surface area of 10,990 ft^2 (1021 m^2). The hydraulic loading rate to the ATS averages over 231,415 GPD (1021 sq m), approximately 29% of the treatment plant's daily capacity. Total nitrogen removal by the ATS for the fall quarter was measured at 4.4 mg/L at a hydraulic loading of 234,849 GPD (889 m^3/d) (Craggs *et al*., 1996).

TABLE 3.7. Calculations based upon performance of Paterson, CA ATS treatment system (Craggs *et al.,* 1996)

WPCP Flow / TN (data year)	ATS Hydraulic & TN Load as % of Total WPCP Load	Expected ATS TN Discharge after ATS Treatment	ATS TN Removal / % ATS Load (% Total WPCP Load)
26th Ward 67 MGD / 13.7 mg/L (2005)	15.2%	9.3 mg/L	336.9 lb/d 32% (5%)
Jamaica Bay 82 MGD / 21.0 mg/L (2005)	11%	16.6 mg/L	336.9 lb/d 21% (2.3%)

The nitrogen removal rates in Table 3.7 may be reasonably expected to occur in the hypothetical Jamaica Bay ATS system described above, under natural solar conditions. However, there is the promising potential to enhance the Jamaica Bay ATS system with the inclusion of artificial lighting and thermo-regulators, which have been shown to improve nutrient removal rates (Adey & Loveland, 1991; Kebede-Westhead *et al*., 2003). There is great potential for ATS systems in the Jamaica Bay watershed to capitalize on the "free" energies from WPCP and landfill gas capture and conversion to heat and power. Utilizing the methane produced from landfills or the WPCP anaerobic digestors fed with algae to power high output lighting and heating systems would augment ATS treatment capacities far beyond the stated treatment rates in Table 3.7, especially during the non-summer seasons. This may provide a cost-effective way to achieve significant treatment with low to no net energy input.

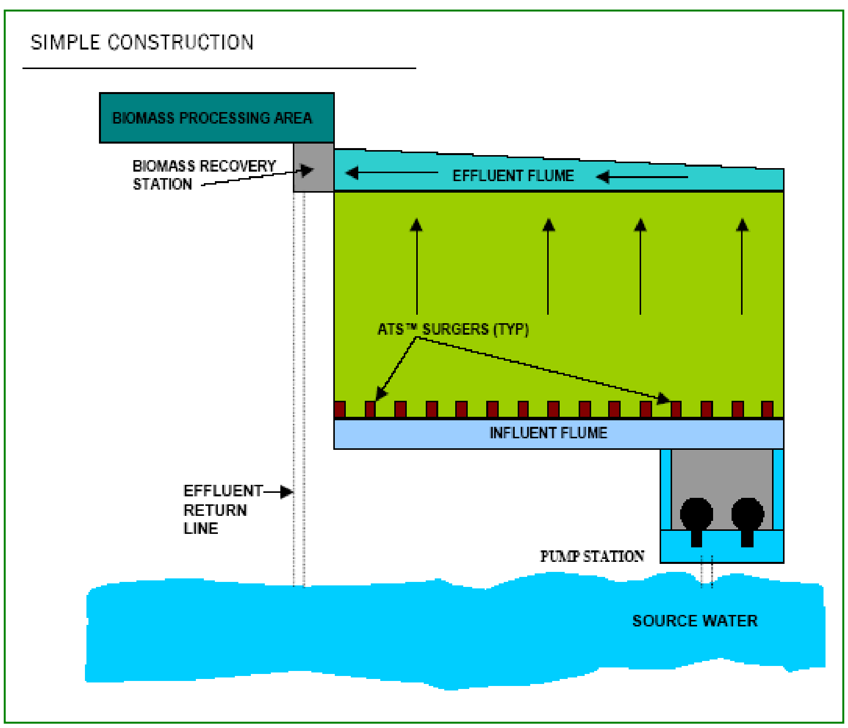


FIGURE 3.5 ATS Flow Schematic; Source: Hydromentia, Inc.

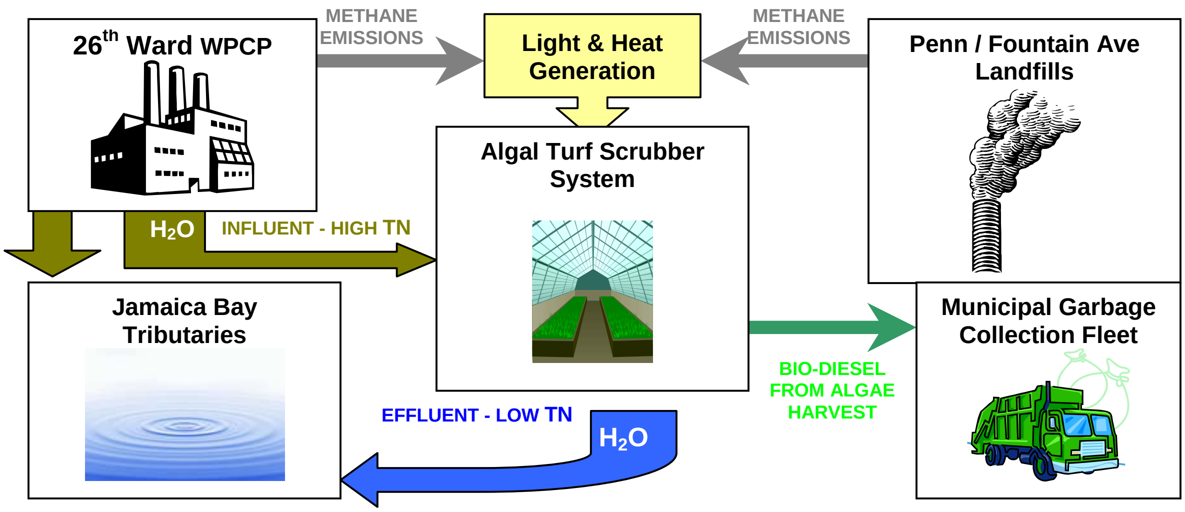


FIGURE 3.6 Schematic Energy Flow Diagram; Source: Biohabitats

Floating Aquatic Vegetation in Final Settling Tanks

While still at the conceptual stage and designs for actual plant selection and configurations have not been developed, NYCDEP will test whether the placement of native floating aquatic vegetation within the final settling tanks (pre-chlorine contact) will have benefits in terms of limited nitrogen removal. Many freshwater wetland plants are notorious for out competing some of the slower grower species and the plants selected for this pilot will need to be evaluated for their invasive potential to avoid adjacent vegetation impacts. However, while this potential is minimized due to the saline waters of Jamaica Bay, the potential for off-site distribution of the selected plants will need to be carefully evaluated.

The principle of placing high nitrogen demanding plants within a nitrogen rich environment is not new and has been applied to constructed wetlands in many other locations. However, while floating aquatic vegetation is typically a nitrogen intensive feeder, the shortened plant/water contact time will limit their full potential for nitrogen removal. High densities may provide additional polishing of the wastewater effluent that, when used in combination with other nitrogen removal technologies, may help to further reduce nitrogen loading.

Technical

Algae and Sea Lettuce Harvesting

In 1993 and 1994, NYCDEP purchased four skimmer boats to service the removal of floatables in New York Harbor tributary waters. Within 24 to 48 hours of significant rain events small vessels are sent out to investigate floating debris from boom and net locations. The inspection vessels are equipped with hand netting tools in order to retrieve small amounts of floatables, allowing the skimmer vessels to focus on servicing sites with larger quantities of material. In dry weather, boom and net inspections occur at least weekly and may occur more often for certain sites where specific tide and wind conditions may cause debris to accumulate. Currently, the skimmer boats are not equipped or capable of removing aquatic vegetation. However, this same schedule/concept could be used to remove algae from known problem areas within Jamaica Bay's open waters and tributaries.

Algal Turf Scrubbers®

Alternative ecologically engineered nutrient removal technologies are emerging as cost-effective methods to achieve water quality goals. The use of natural processes in controlled, ecologically engineered systems are designed and managed to improve water quality in ways that are less expensive, more ecologically sound and provide a greater number of wildlife habitats than traditional technologies (Craggs *et al*., 1996). These processes are found in a range of proposed treatment options, including: algal turf scrubbers, constructed wetlands (included with the on-site and off-site stormwater management BMPs identified under Stormwater Management through Sound Land Use), and bivalve (*e.g.,* oyster) filtration. These alternative methods, either alone or in combination, have the potential to offer economical water treatment for Jamaica Bay's WPCPs while providing considerable secondary ecological benefits. These "soft" technologies are not meant to replace the "hard" engineering solutions as they could not adequately treat the volume of wastewater and stormwater run-off. Rather, they would supplement these techniques to further improve water quality and increase ecological diversity. The JBWPP will implement pilot studies employing each of these treatment options based on the reported nutrient (TN) removal capabilities of each technology and the secondary ecological benefits.

Traditional primary and secondary wastewater treatment systems are optimal for microbial degradation of organic wastes but provide for limited removal of nutrients (Metcalf and Eddy, 1991). Tertiary treatment through physical and chemical or alternate microbial processes are widely used but costly to implement and can be variable in their performance (Randal *et al*., 1990).

A notable hindrance to widespread application of ecological engineering technologies is the amount of area required to achieve desired levels of treatment given the daily effluent volumes generated from each of the Jamaica Bay WPCPs. The following analysis is intended to explore the feasibility of employing each of these treatment options based on the reported nutrient (total nitrogen, TN) removal capabilities of each technology, secondary ecological benefits, specific design constraints, and the risks of implementation.

Land availability is the primary limiting factor to consider when evaluating the treatment potential for ATS systems at WPCPs with large discharges, such as those in the Jamaica Bay watershed. However, it is worth noting that ATS systems are typically non-permanent structures which can be easily disassembled or transported. Often, they are located in greenhouses. For New York State tax purposes some greenhouses are considered non-permanent "temporary" structures (NY State Real Property Tax Law Section 483-C).

The 26th Ward WPCP property includes an 11-acre parcel that historically was used for sludge storage and is currently vacant. Assuming that 10 acres are potentially available for ATS coverage, TN concentration reduction and load removal is calculated for the 26th Ward WPCP using the nitrogen removal rates and effective hydraulic loading capacity demonstrated by the Patterson, CA ATS system (Table 3.7). Although land availability proximate to the Jamaica Bay WPCP is very limited, analogous calculations for the Jamaica Bay WPCP are included here for comparison purposes.

ATS systems require no excavation, are easily constructed, have significant potential in the re-use of algae as a fertilizer or energy byproduct, and are on the "cutting edge" of ecologically engineered water treatment technologies. Provided space is available, a small-scale, pilot ATS system is recommended at the 11-acre sludge storage space available on the 26th Ward WPCP property. Upon successful implementation and demonstrated treatment capability, there is the potential to scale up to a methane emission-powered greenhouse ATS system on all 11 acres.

Oyster Restoration

Oysters are a "keystone" species and were once a prominent feature within Jamaica Bay, and the effect on the ecology of the Bay from their absence is not fully understood. A fundamental premise of the JBWPP is to improve the ecology of Jamaica Bay. Returning a keystone species, like the oyster, to the Jamaica Bay ecosystem may provide additional benefits well beyond the physical limits of the restoration location. Historically, their large filtering capacity likely played a key role in helping to improve water quality within Jamaica Bay and provided significant wildlife habitat benefits. Therefore, to help improve the ecology of the Bay and provide water quality improvements from bivalve filtering, an oyster restoration pilot is being proposed in areas of the Bay that provide suitable habitat. An example location may be near the mouth of Hendrix Creek or in a location that may serve as a natural wave attenuator near existing salt marsh islands. Additional input from Jamaica Bay stakeholders is required to determine the most successful and beneficial location.

Ribbed Mussel Restoration

While ribbed mussels currently exist within the Bay, their densities may not be at historic high levels to affect change within the water column. From a filtering standpoint, the current densities may be limiting their full potential filtering capacity and associated benefits. Therefore, the strategic placement of high density ribbed mussel beds in CSO tributaries may provide another important tool to help reduce pathogen levels from CSO events and improve water quality within the affected tributaries. Through a pilot study, the filtering capacity and required densities of ribbed mussels to improve water quality will be evaluated.

Legal

For the oyster and eel grass restorations, wetland and water quality permits will be required from NYSDEC and USACE. In addition, attractive nuisance controls for the oysters will be required by the New York State Department of Health (NYSDOH). There are no known issues for the implementation of the algal turf scrubber system.

Cost

NYCDEP will pilot a number of the measures discussed above. For costs related to these pilots, see *Implementation Strategies* below.

RECOMMENDATION

It is recommended that the City pursue pilot projects for algae harvesting, algal turf scrubbers, oyster and eel grass restoration and ribbed mussel beds. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

The pilot studies discussed below are needed because the alternative technologies evaluated in the section are new and have not been implemented on a large scale basis. The pilot studies would be intended to address the uncertainties discussed above under environmental and technical issues.

Algae and Sea Lettuce Harvesting Pilot Study

Using tide information and information from local sources, estimate locations where sea lettuce accumulates. Further, NYCDEP will develop and implement a pilot study to determine if algae harvesting with the use of NYCDEP skimmer boats is a feasible and cost-effective method to remove algae from Jamaica Bay and select tributaries. This pilot study will be implemented in consultation with relevant groups to determine temporal events and known locations of algae accumulation. Additional information regarding the unique conditions of the Bay, as described above, is required.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: $387,000.

Algal Turf Scrubbers®

Large-scale implementation will be assessed upon completion of a pilot study to determine the most effective configuration.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: $350,000.

Oyster and Eel Grass Restoration Pilot Study

NYCDEP will develop and implement these pilots in consultation with relevant groups to determine the most ideal candidate locations.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: Oyster restoration $600,000; eel grass restoration: $350,000.

Ribbed Mussel Restoration Pilot Study

NYCDEP will develop and implement this pilot in consultation with relevant groups to determine the most ideal candidate locations.

Schedule: Pilot study will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: Ribbed mussel restoration $300,000.

Management Strategy 1a3: Limit processing of additional centrate from WPCPs outside of Jamaica Bay.

STRATEGY DESCRIPTION

After ocean disposal of sewage sludge ended in 1992, several NYCDEP WPCPs needed to dewater sludge, or the solids that remain after the wastewater treatment process, to reduce the weight and volume for long-distance transport. The nitrogen-rich water taken from dewatered sewage sludge, known as centrate, is recirculated into the treatment plants for processing, and is ultimately discharged (after a reintroduction to the treatment plant and subsequent nitrogen removal processes) into the Bay's waters. The centrate contains high concentrations of Total Kjeldahl Nitrogen (TKN), typically between 800 mg/l and 1,100 mg/l, and can cause an increase in the nitrogen effluent loadings from the plants. However, the use of BNR systems can remove a significant amount of the nitrogen contained within the centrate before discharging to local receiving waterbodies.

Currently, NYCDEP has the ability to dewater sludge at eight of the City's 14 treatment plants around the City. Sludge dewatering facilities exist at the Tallman Island, Bowery Bay, Wards Island, Red Hook, Oakwood Beach, Hunts Point, Jamaica and 26th Ward WPCPs.

NYCDEP transports sludge from the 14 WPCPs generating sludge to the 8 WPCPs that contain sludge dewatering equipment using a series of forcemains and the fleet of sludge vessels that was previously used to ship sludge to the ocean for disposal. Sludge shipment and dewatering schedules are flexible and highly variable. When and where sludge shipments are made is dictated by a number of factors including.

- Availability and location of sludge vessels;
- Availability of sludge dewatering capacity at the WPCPs;
- Environmental pressures to reduce effluent nitrogen loadings to both the Upper East River and Jamaica Bay; and
- Sludge treatment limitations associated with WPCP construction activities.

Table 3.8 below shows the movement of sludge that was shipped via vessel and how it was moved from one WPCP to another during 2006. This table only represents the portion of the sludge that was shipped and is not meant to show the destination of all of the sludge. For example, even though the Bowery Bay WPCP has the ability to dewater its own sludge, some sludge was exported from Bowery Bay in 2006; this is typically done if the Bowery Bay WPCP's dewatering system is down for maintenance. Of the quantity shipped from the Bowery Bay WPCP, almost 80 percent was shipped to the Hunts Point WPCP and the remaining 20 percent was shipped to the Wards Island WPCP.

The table shows that in 2006, the 26th Ward WPCP received sludge from the Newtown Creek, North River, Owls Head, Port Richmond and Rockaway WPCPs via vessel shipment, totaling just under 10% of the total centrate processed at the 26th Ward WPCP that originated from outside Jamaica Bay.

TABLE 3.8 . Destination of the Vessel-Shipped Sludge

		Hunts Point	26th Ward	Wards Island
Shipments of Sludge via Vessels from WPCPs*	*Bowery Bay*	79.8%		20.2%
	Newtown Creek	54.0%	0.7%	45.3%
	North River	50.6%	0.6%	48.7%
	Owl's Head	57.4%	5.5%	37.1%
	Port Richmond	55.4%	3.1%	41.5%
	Red Hook	56.4%		43.6%
	Rockaway	3.2%	94.8%	2.0%
	Tallman Island	63.5%		36.5%
	Wards Island	100%		

* This percentage only represents the amount of sludge that was shipped *from* the WPCP in 2006.

However, during the period from 2004-2006, there was a slightly different configuration. On average during that period, 14 percent of the sludge treated at the 26th Ward WPCP was received by vessels that came from WPCPs outside Jamaica Bay. However, as shown in the graphic below, the vast majority (85 percent) came from WPCPs within Jamaica Bay (see Figure 3.7 below).

During the 2004 to 2006 period NYCDEP made efforts to reduce the amount of sludge shipped into Jamaica Bay, from the Owls Head WPCP in particular. As a result of construction restrictions at the 26th Ward WPCP, the percentage of sludge transported by vessel (from WPCPs outside of the Bay) has dropped from 23 percent in 2004 to 7 percent in 2006 (see Figure 3.8).

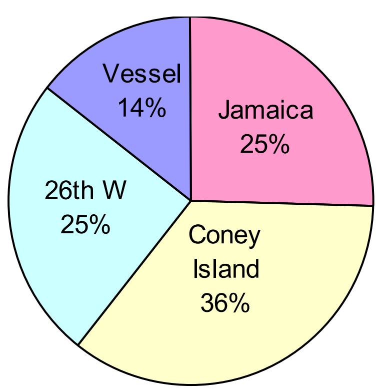


FIGURE 3.7 26th Ward Sludge Breakdown (2004-2006); Source: NYCDEP

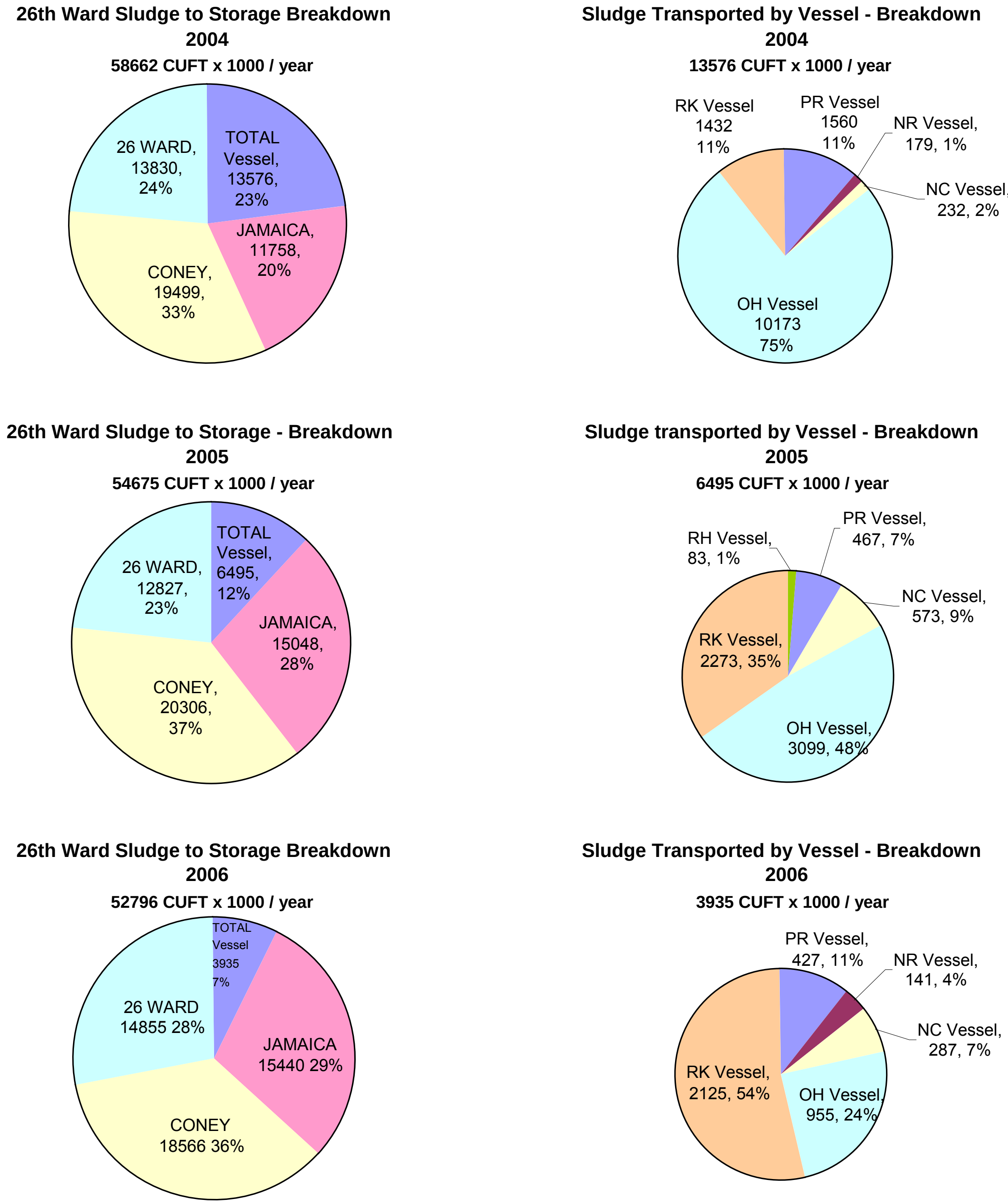


FIGURE 3.8 Sludge to Dewatering Facility at 26th Ward – Breakdown; Source: NYCDEP

NYCDEP has attempted to limit the shipment of sludge from WPCPs outside of Jamaica Bay for processing at the 26th Ward WPCP. However, due to operational concerns, routine plant maintenance, or other unforeseen events at the other wastewater treatment facilities, NYCDEP needs to keep this treatment option "open" for potential future use through at least mid 2009. However, best efforts will be made to limit, to the greatest extent possible, centrate from outside of Jamaica Bay.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

In 2006, approximately 10,800 lb TN/day arrived at the 26th Ward WPCP as influent from sanitary sewage. An additional 6,800 lb/day of TN arrived in the form of nitrogen from sludge dewatering centrate, for a total of 17,600 lb/day. Modeling was performed to determine whether reducing centrate treatment at 26th Ward WPCP would impact nitrogen loading in the Bay. Preliminary BioWin modeling has indicated that some centrate load at the 26th Ward and Jamaica WPCPs has a seeding affect that benefits the overall Nitrogen removal process. Data review of this work is ongoing and will be shared with NYSDEC in the coming months as negotiations continue on the CJBWQP.

The sludge delivered from WPCPs outside of Jamaica Bay has a relatively small impact on the concentration of total nitrogen within Jamaica Bay. The analyses indicate that no discernable benefit is obtained by changing practices relative to sludge dewatering processing and centrate treatment within Jamaica Bay.

Legal

Consistent with the Nitrogen Consent Order, NYCDEP must make best efforts not to ship sludge from the Owls Head WPCP to the 26th Ward WPCP. Sludge from the Bowery Bay and Tallman Island WPCPs is mandated to be transshipped to a visitor WPCP effective July 1, 2009 through the end of Phase I construction at each facility. Phase I construction is scheduled to conclude on December 31, 2010 at Tallman Island and December 31, 2011 at Bowery Bay. There are no apparent legal restrictions on the destination of Tallman Island and Bowery Bay sludge, and the NYCDEP may choose to restart dewatering operations at these facilities after Phase I construction has concluded.

RECOMMENDATION

NYCDEP will continue to minimize trans-shipment of centrate into Jamaica Bay. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Continue to Minimize Transshipment of Sludge to Jamaica Bay

NYCDEP will continue its efforts to minimize trans-shipment of centrate to Jamaica Bay. In addition, it will make best efforts not to ship centrate from Bowery Bay and Tallman Island to Jamaica Bay. However, due to operational considerations and construction upgrades at other WPCPs, NYCDEP will need to have the option to ship sludge to the 26th Ward WPCP for dewatering so long as the effect on the TN loading to Jamaica Bay is minimal. NYCDEP requires this flexibility because there are limited options and facilities where sludge can be treated. Furthermore, NYCDEP has invested substantially in sludge dewatering equipment. NYCDEP will continue to evaluate where it can ship its sludge, consistent with its commitments to NYSDEC to not ship Bowery Bay and Tallman Island sludge into Jamaica Bay.

Schedule: Ongoing.

Cost: Not Applicable.

OBJECTIVE 1B: REDUCE CSO AND OTHER DISCHARGES INTO THE TRIBUTARY BASINS TO IMPROVE PATHOGEN AND DO LEVELS.

Current Programs

Addressing CSO discharges is a high priority for NYCDEP with ongoing Long Term Control Plan (LTCP) efforts in Fresh, Hendrix, and Spring Creeks as well as Bergen and Thurston Basins. (See Volume I, Chapter 3, "Water Quality" for a discussion of the LTCP.) In 1972, a facility at Spring Creek (Spring Creek Auxiliary WPCP (AWPCP)) was constructed to store 12 to 20 million gallons of CSO discharges and redirects it to the 26th Ward WPCP for treatment. This facility recently completed a stabilization and modernization upgrade to ensure that it will continue to operate as designed for many years into the future. Also in the 26th Ward WPCP drainage area, NYCDEP plans to clean selected sewers, dredge Hendrix Creek to remove accumulated sediment, and expand the 26th Ward WPCP to capture an additional 50 MGD.

In the Jamaica WPCP drainage area, NYCDEP is developing a drainage plan to separate storm and sanitary sewers in southeast Queens. NYCDEP will be moving forward with the design of a high level storm sewer system (HLSS) in the Laurelton section of the Thurston Basin drainage area once the Southeast Drainage Plan is completed. Further, NYCDEP will construct a new 48-inch inverted siphon under the Belt Parkway, enlarge the orifice at Regulator #3, and automate Regulator #2 to address hydraulic limitations that constrict wet weather flow to the Jamaica treatment facility, thereby capturing more wet weather flow for treatment.

NYCDEP is constructing a CSO retention facility for Paerdegat Basin in the Coney Island WPCP drainage area, to capture the first 50 million gallons of CSO from each rainfall event and to treat the overflow from larger events for floatables and settleable solids removal. In the Rockaway WPCP drainage area, NYCDEP is continuing to address flooding issues and sanitary connections in the Jamaica Bay watershed through construction of new storm sewers and correcting improper sewer connections, respectively.

NYCDEP is actively addressing the few remaining neighborhoods around Jamaica Bay that do not have public sewer service and therefore must use septic systems that often under-perform, storage tanks that require frequent pump-out, or illegal outfall pipes that discharge directly into surface waters. NYCDEP is currently constructing sewers in the Warnerville and Meadowmere sections of eastern Queens and is undertaking a storm sewer and sanitary sewer project along the Jewel Streets in Howard Beach.

While investing in new infrastructure, it is equally critical to maintain the existing system NYCDEP programmatically inspects its catch basins and regulators and responds to complaints related to sewer back-ups and maintenance. NYCDEP is investigating the expansion of its scheduled maintenance program to include sewers and interceptors.

The below initiatives to reduce CSO discharges are discussed in detail below under three management strategies:

- Maximize the existing sewer system through maintenance (Strategy 1c1);
- Reduce CSO discharges through sewer and treatment facility infrastructure improvements (Strategy 1c2); and
- Provide sanitary sewage treatment service to the remaining un-sewered neighborhoods along margins of the Bay (Strategy 1c3).

Strategy 1b1: Maximize the existing sewer system through maintenance.

STRATEGY DESCRIPTION

The historical development of the sewer system in New York City shows that the initial primary objectives were to alleviate street flooding, prevent sewer "back-ups," and transport wastes from properties. As knowledge was gained on the effects of waste products on water quality and human health, the City built "intercepting sewers" at the outfalls of the "combined" sewers to convey dry weather flow, as illustrated in Figure 3.11, to "new" sewage treatment plants. These intercepting sewers and the new treatment plants are designed to convey and treat up to two times design dry weather flow (DDWF). During wet weather, flow in the combined sewers that exceeds two times DDWF is diverted at regulators to the receiving waters via CSO.

Along with recommending construction solutions to reduce CSO discharges, this strategy encourages optimizing capacity of the existing sewer system to deliver wet weather flows to WPCPs. This will be accomplished through enhancements to NYCDEP's cleaning and maintenance program. With respect to controlling CSOs, maintenance of regulators and interceptors are most critical because they determine how much flow is directed to the WPCP as opposed to the CSO outfall.

Catch Basin Maintenance

Stormwater enters the system through catch basins along roadways. Catch basins are designed to maximize floatables capture, prevent them from entering the sewer system, and potentially leaving through a CSO. Maintaining optimal catch basin performance includes hood installation (see Figure 3.9) and programmatic catch basin cleaning. in addition to keeping floatables away from the sewer system, hooding catch basins and cleaning them regularly with a hydraulic scoop that removes the sediments, allows the maximum use of storage space before the rain flows into the sewer and helps to reduce downstream interceptor sedimentation.

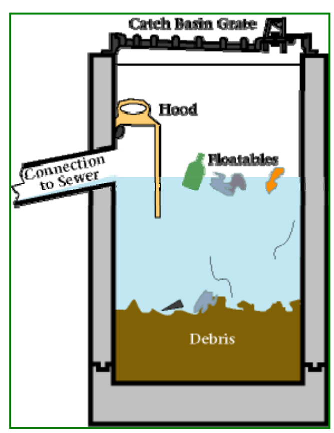


FIGURE 3.9 NYCDEP Catch Basin with Hood; Source: NYCDEP

During the course of the recent catch basin hooding program, over 4,000 catch basins were reconstructed in Jamaica Bay to allow them to be hooded. As of the April 2007, all catch basins that needed to be reconstructed in order to accommodate hooding have been either reconstructed or submitted to New York City Department of Design and Construction (NYCDDC) for reconstruction and will be completed by 2010.

As part of NYCDEP's regular maintenance program as required by the SPDES permit, crews inspect each catch basin once every three years and clean or repair catch basins based on inspection results. Along with the programmatic inspecting and cleaning, NYCDEP also responds to 311 complaints and cleans any clogged basins. 311 is New York City's phone number to contact NYCDEP and all other government agencies for information and non-emergency services.

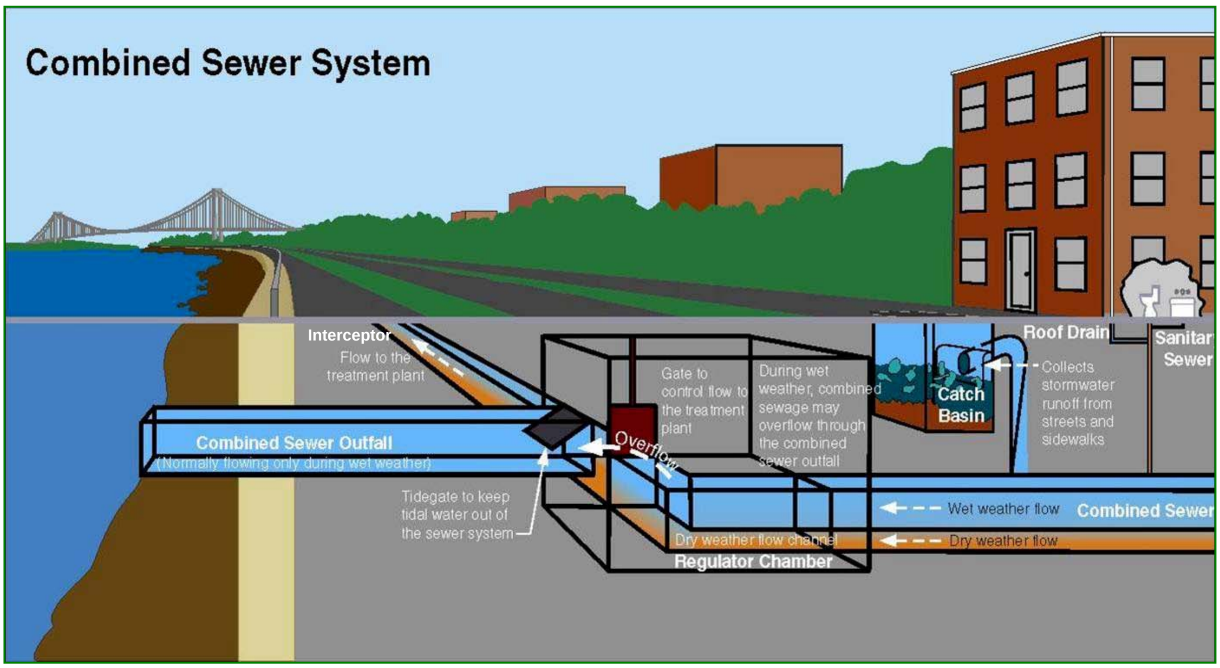


FIGURE 3.10 NYCDEP Combined Sewer System Diagram; Source: NYCDEP

Throughout Brooklyn and Queens, 24,446 were cleaned in 2006 out of the 36,682 catch basins that were cleaned citywide. Of the 48,542 catch basins in Jamaica Bay watershed, all were inspected, and 35,406 were cleaned at least once between January 2002 and June 2007. Of those that were cleaned during this period, 20 catch basins received 10 or more cleanings; past reasons include proximity to an under-performing seepage basin and excessive litter from hydrant flow, street sweeping or bus stops. However, NYCDEP's current program quickly addresses complaints and cleans all necessary catch basins as determined by the programmatic inspection.

Sewer Maintenance

Sewers are rodded and flushed periodically based on complaints as well as direct observation of excessive solids accumulation during Closed Circuit Television (CCTV) inspection. *Rodding* uses a flexible metal rod to dislodge material blocking the sewer; *flushing* injects high pressure water upstream of the problem area to dislodge the blockage. When a sewer is inspected, NYCDEP will first clean the sewer and then inspect the sewer for structural integrity through CCTV. Roughly 2% of the system is inspected each year via the current televising method. Repair, cleaning and maintenance of the sewer system is required in the SPDES permit requirements under the CSO Maintenance and Inspection Program and the Maximum Use of Collection System for Storage.

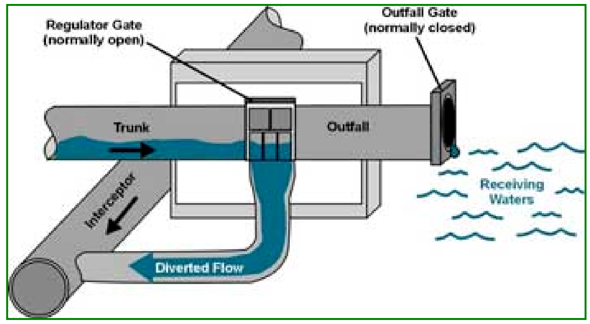


FIGURE 3.11 Regulator Image from King County, WA, Source: King County Wastewater Treatment Division

Sewer back up data were analyzed from January 2002 to May 2007. Sewer backups are reported to NYCDEP by 311 complaints and could be caused by a number of different factors including excess sediment that has settled within the sewer, an invasion of tree roots into the sewer, a physical obstruction such as a large piece of debris becoming lodged in the sewer, or other similar circumstances. The analysis found that the sewers needing repeated rodding or flushing were inland within the Jamaica WPCP drainage area. This area is separately sewered and blockages would not impact combined sewer overflows. Nevertheless, preventative maintenance for sewers will remove sediment and maximize the storage and transmission capacity of the current infrastructure.

Regulators

Regulators direct stormwater and wastewater to interceptors and then to CSOs once the system reaches its capacity during wet weather events. Interceptors are large sewers that connect the system via regulators to treatment plants and are built to deliver at least two times design dry weather flow. Regulators throughout the city have been designated as either high priority or normal priority. High priority regulators convey at least five million gallons per day and/or inherently require high maintenance. Regulators that pose a threat to beaches ("beach-sensitive") are also high priority and fall under the Enhanced Beach Protection Program, as described below. NYCDEP's regular inspection and maintenance program for regulators is part of the Nine Minimum Controls (NMCs) as defined by the U.S. Environmental Protection Agency's (USEPA's) National CSO Control Policy and included in the SPDES permit for all WPCPs.

Of the 490 regulators in New York City, 49 regulators are within the Jamaica Bay watershed, including seven beach-sensitive high priority, four high priority and 38 normal priority regulators. NYCDEP inspects high priority regulators four times a month and normal regulators once a month. Between the months of May and September, all beach sensitive regulators and pumping stations are monitored daily under the Enhanced Beach Protection Program. To further reduce dry weather bypasses, NYCDEP has installed automated monitoring systems in 100 regulators and all pumping stations. Every high priority regulator in the Jamaica Bay watershed has a telemetry system installed.

Field crews inspect the entire regulator and fill out an inspection report for each visit. Crews are required to fix any problems they encounter that would affect the regulator's operation. If a problem occurs that is beyond the crew's capabilities, an emergency contractor is called; the contractor is required to respond within 24 hours.

Pumping Stations

Pumping stations direct combined and separate flow to downstream locations in the City's sewer infrastructure when gravity cannot direct the flow. Along with regulators and interceptors, pumping stations control the amount of flow a WPCP will receive and how much will be discharged through a CSO. The Jamaica Bay watershed has nine pumping stations: two in the Coney Island WPCP drainage area, three in the Jamaica drainage area, four in the Rockaway drainage area, and none in the 26^{th} Ward drainage area.

Interceptors

Interceptors are large sewers that connect the collection system to treatment plants, and are typically sized to deliver two times design dry weather flow to treatment plants. Currently, NYCDEP removes debris and sediments from interceptors on an as-needed basis. Interceptors are particularly critical for reducing CSOs because they dictate how much flow gets to the WPCP. If they are constricted with debris, they may trigger an earlier than necessary CSO event.

Between 1999 and 2000, the interceptor beneath JFK Airport was cleaned to increase the wet weather flow captured by the Jamaica WPCP. During the cleaning, 3,500-3,600 cubic yards of grit were removed. In 2005 segments of the west interceptor were also cleaned for the same reason. Although the cleaning maximized flow within the interceptor, the average wet weather flow that reaches the plant is still below the design of 200 MGD. Hydraulic modeling was used to isolate the cause of this diminished flow and two regulators along with segments of the west interceptor were identified as limiting the amount of wet weather flow reaching the plant. The strategies for upgrading the regulators to address this conveyance issue are discussed in Management Strategy 1c2.

STRATEGY EVALUATION

Maximizing the capture rates and storage capacity within the existing sewer infrastructure will have a positive environmental benefit as more combined sewage will be directed to and be treated by the WPCP. With respect to minimizing CSOs, interceptors and regulators are most significant as they dictate how much of the combined sewage can be conveyed to the plant and how much will be discharged to surrounding waters. Keeping catch basins and sewers clean will reduce back-ups and concomitant flooding; this sediment reduction would likely have a positive effect on CSOs as well. There are no significant technical or legal obstacles to the implementation of this strategy. Resource constraints are the primary obstacle to expanding NYCDEP's current programs. Costs for program elements are discussed below under specific *Implementation Strategies*.

RECOMMENDATION

It is recommended that the City continue its current maintenance program for catch basins and regulators and develop an enhanced program for maintaining sewers and interceptors, pending additional funding. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

NYCDEP is developing a more proactive approach to the maintenance and cleaning of the sewer infrastructure to ensure that sewer infrastructure reaches its maximum capacity during wet weather. Programs, such as cleaning sewers in the 26^{th} Ward drainage area, and pilot studies for preventative maintenance for sewers and interceptors and the catch basin maintenance program, show NYCDEP's commitment to keeping its infrastructure working at optimum capacity.

Expanded Sewer Cleaning Program

A programmatic sewer inspection and cleaning program is in development and would increase the current inspection rate from approximately 2% to 7-10% annually. At this increased rate, the entire sewer system would be inspected every 10 to 14 years. This would create a preventative program rather than the current one that largely responds to complaints. The proposed inspection program follows guidance from a potential USEPA regulation that would extend the Capacity Management Operation and Maintenance (CMOM) program required for sanitary sewer overflows to combined sewer overflows as well.

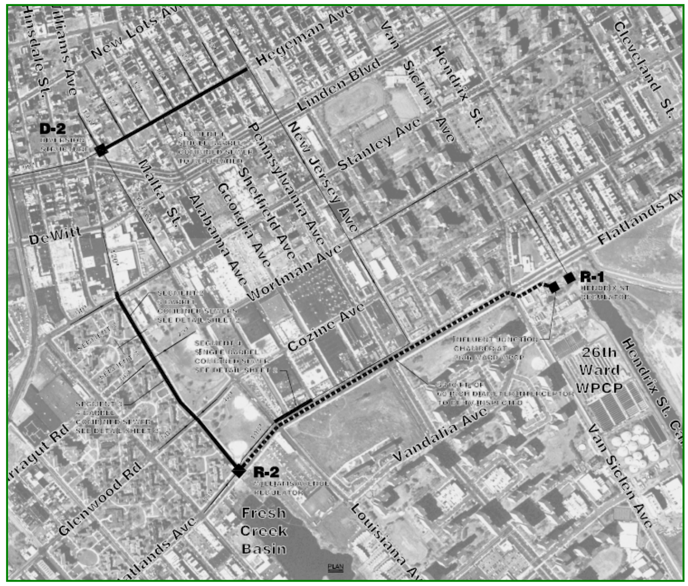


FIGURE 3.12 26th Ward Sewer Cleaning Plan, June 2007; Source: NYCDEP

Cost: Inspecting 7% of the sewers annually would cost approximately $2.5 million per year. The program has been funded until 2009.

Schedule: A pilot study will be initiated in 2008. One year of the full scale program will be completed in 2009.

26th Ward Sewer Cleaning Project

As part of the 2005 CSO Consent Order, NYCDEP will be undertaking a sewer cleaning project in the 26th Ward WPCP drainage area. NYCDEP will remove sediments from sewers that have been identified as bottlenecks in the system along Williams Street, Hegeman Avenue and Flatlands Avenue (see Figure 3.12 26th Ward Sewer Cleaning Plan).

The cleaning project will have the effect of redirecting the dry and wet weather flow from the Williams Avenue regulator (that discharges to Fresh Creek) to the Hendrix Street regulator (that discharges to Hendrix Street Canal). The sewer cleaning will allow the regulators to handle more wet weather flow.

An evaluation of the effectiveness of sewer cleaning to affect the dry and wet weather flows as predicted will be undertaken by NYCDEP and will inform the broader sewer cleaning program discussed above.

Cost: The 26th Ward Sewer Cleaning Project will cost approximately $4 million.

Schedule: This project has been designed and bid. Cleaning is scheduled to begin on or before June 2008 and completed on or before June 2010.

Expanded Interceptor Inspection and Maintenance

NYCDEP is undertaking an assessment of the entire intercepting sewer system to determine the structural integrity and operational conditions such as sedimentation and grease buildup. Sonar will be utilized to profile the bottom of each interceptor while simultaneously CCTV will be used to evaluate the structural condition of the surface above the water level. Repair, rehabilitation, and cleaning programs will be developed based on the assessment results.

The assessment program will be piloted in the Rockaway WPCP drainage area this year as well as in the Oakwood Beach WPCP drainage area. In the Rockaways, the pilot will inspect the entire east interceptor of the Rockaway WPCP. Once the pilot has been completed, a citywide inspection will be undertaken. Programmatic maintenance of interceptors is a key component to ensuring that the existing sewer system reaches its maximum storage and conveyance capabilities during wet weather, thereby potentially reducing CSO quantity and frequency.

Schedule: The pilot studies will be completed in 2008 and the citywide inspection is expected to be completed by 2010. Once the inspection is complete, a cleaning program and scheduled maintenance plan will be devised.

Cost: Approximately $300,000 for the pilot projects and $4 to 5 million to complete the citywide inspection program. The cleaning and maintenance program costs will be determined once the inspection program is complete.

Management Strategy 1b2: Reduce CSO discharges through sewer and treatment facility infrastructure improvements.

STRATEGY DESCRIPTION

The strategy includes projects mandated under the CSO consent order and/or proposed under the *Jamaica Bay and CSO Tributaries Waterbody/Watershed Facility Plan (WB/WS Plan)* submitted to the NYSDEC in June 2007 as part of the CSO LTCP. Also included in this section is the Paerdegat Basin LTCP that was developed in the *Paerdegat Basin LTCP* submitted to the NYSDEC in November 2005 and revised in June 2006. The projects focus on reducing CSO discharges and abating pathogen loading through off-line storage, WPCP facility enhancement, and high-level storm sewer design. The WB/WS Plan also considered in-line storage as a potential future option to achieve higher CSO capture levels.

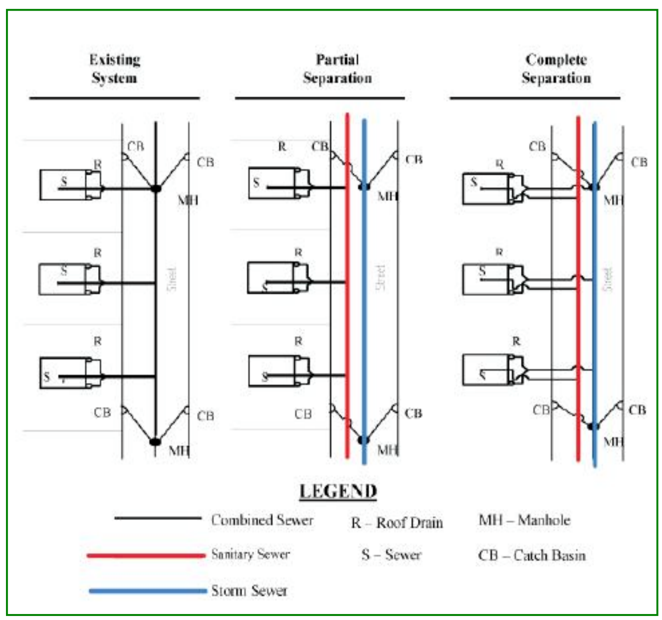


FIGURE 3.13 Sewer Separation Alternatives; Source: NYCDEP

Off-line storage is accomplished through storage facilities that are located outside the sewer conveyance system and WPCPs. Off-line storage reduces overflows by capturing combined sewage that WPCPs cannot handle during wet weather. After the storm event, the combined sewage is directed for controlled release back to the WPCPs.

In-line storage, or in-system storage, uses excess sewer capacity by containing combined sewage within a sewer and releasing it to the WPCP after a storm event. In-line storage includes storage tunnels, mechanical gates, and increased weir elevations.

WPCP Enhancement includes expanding or upgrading the facility to increase wet weather capture and treatment.

High Level Storm Sewers (HLSS) are created by removing the catch basin connection from the combined sewer combined sewers under streets or in the public right-of-way and connecting to a new storm sewer. This type of separation is also called *partial separation*. *Complete separation*, on the other hand, involves separation of stormwater runoff from private residences or buildings (*i.e.,* rooftops and parking lots) in addition to separation of sewers in the streets. Figure 3-13 illustrates these two types of sewer separation. Complete separation is very difficult to attain in New York City since it requires redesigning the plumbing within all properties where roof drains are interconnected to the sanitary plumbing inside the building.

The following sections discuss these strategies by WPCP drainage area. For additional information on these projects, please refer to the *Jamaica Bay and CSO Tributaries Waterbody/Watershed Facility Plan* and the *Paerdegat Basin LTCP*.

26th Ward WPCP Drainage Area

NYCDEP is currently proposing the following elements to reduce CSOs and improve water quality in the 26th Ward WPCP drainage area:

- **50 MGD Wet Weather Expansion for 26th Ward WPCP** – Increasing the treatment plant's wet weather capacity from 170 MGD to 220 MGD involves the construction of new primary settling tanks, a new chlorine contact chamber, and other related items (additional pumps, expansion of headworks building, and electrical work).

- **Spring Creek AWPCP Upgrade –** The AWPCP upgrade, which serves portions of the 26th Ward and Jamaica WPCP drainage areas, was completed in April 2007. The upgrade involved increasing floatable control and combined sewage treatment as well as providing a minimum of 20 MG of CSO storage. The Spring Creek AWPCP captures CSO at the Spring Creek outfall and provides settling and floatables removal from the influent. Once a storm event passes, stored flow is redirected to the Coney Island WPCP for treatment.

- **In-line Storage in Hendrix Creek –** As part of the LTCP, NYCDEP will further evaluate adding a bendable weir to the Hendrix Creek outfall for CSO abatement.

- **In-stream Aeration** – Discussed in Management Strategy 1c2.

- **Sewer Cleaning Project** – Discussed in Management Strategy 1b1.

- **Hendrix Creek Dredging** – Discussed in Management Strategy 1c1.

The WB/WS Plan also includes evaluations of other measures to reduce CSOs including complete separation of the combined sewers in the 26th Ward WPCP collection system, storage tunnels near Fresh Creek, and in-stream aeration in Fresh Creek. While many of these projects are still under evaluation for potential incorporation into future plans, most show minimal improvement for DO levels although, as discussed in Management Strategy 1c2, NYCDEP is actively pursing in-stream aeration to attain DO water quality standards.

Jamaica WPCP Drainage Area

- **Southeast Queens Drainage Plan –** NYCDEP is developing the drainage plan for the Laurelton and Springfield Boulevard areas of southeast Queens (Southeast Queens Drainage Plan). This area, as shown in Figure 3.15, includes Drainage Districts 41 SWB, 42 SW and 42, and involves sewer system modifications that are necessary to convert the existing system to one that is basically separated. Specifically, the Laurelton area (Drainage District 42) will be converted from a combined system to one that is serviced by HLSSs as well as other elements that would maximize separate sewers and minimize combined sewers. This plan will summarize the required work to construct the sewer system in accordance with the City's Drainage Plan, correct sewer and street flooding problems, and minimize combined sewer overflows.

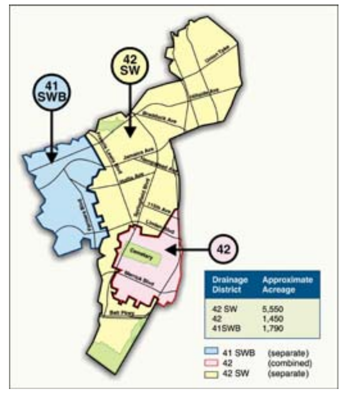


FIGURE 3.14 Portion of SE Queens Drainage Plan; Source: NYCDEP

  Another item being addressed in the drainage plan is whether NYCDEP can prevent stormwater generated in the 5,550 acre separately sewered drainage area upstream of Laurelton (42 SW) from mixing with the remaining portion of the HLSS via a new diversion storm sewer on Hollis Avenue. By constructing the Laurelton HLSS system and the Hollis Avenue stormwater diversion piping, the existing combined and storm sewer interceptors that run southerly under Springfield Boulevard (towards Thurston Basin) would convey stormwater flow only and, therefore, minimize CSOs.

- **Regulator Improvements at Bergen Basin –** As mentioned in the previous strategy, hydraulic limitations constrict wet weather flow to the Jamaica treatment facility. To address these limitations, NYCDEP will construct a new 48-inch inverted siphon, enlarge the orifice at Regulator #3, and automate Regulator #2. The new siphon will complement the existing dual 36 inch inverted siphon under the Belt Parkway. Regulator #3 orifice will be enlarged from 36 inch by 48 inch to 60 inch by 66 inch. This enlargement will address the back-up of wet weather flows in the interceptor and the resulting overflow of combined sewage at Regulators #3 and #14. Through an electro-hydraulic actuator, Regulator #2 will direct dry weather flow to Jamaica WPCP and a portion of wet weather flow to Spring Creek AWPCP.

- **In-stream Aeration for Bergin and Thurston Basins** – Discussed in Management Strategy 1e2

Coney Island WPCP Drainage Area

- **Paerdegat CSO Retention Facility –** NYCDEP is constructing a retention facility in Paerdegat Basin. The 50 MG facility will capture CSOs at the Paerdegat Basin outfall and provide settling and floatables removal from the influent. Once a storm event passes, the stored flow will be redirected to the Coney Island WPCP for treatment.

Rockaway WPCP Drainage Area

- **Complete sewer separation** – NYCDEP will reconstruct the sewers in the Rockaway WPCP drainage area. Many of the sewers in the western section of the drainage area have already been separated and NYCDEP intends to continue its current program to separate Rockaway sewers over time.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

As shown on Table 3.9, the strategies discussed above will reduce CSOs and improve water quality conditions within the Jamaica Bay Tributaries as discussed in more detail in the WB/WS Report.

TABLE 3.9. Annual Water Quality Benefits*

Tributary	Dissolved Oxygen *Baseline*	Dissolved Oxygen *Future*	Total Coliform *Baseline*	Total Coliform *Future*	Fecal Coliform *Baseline*	Fecal Coliform *Future*
Fresh Creek	60%	72%; 100%	58%	100%	33%	83%
Hendrix Creek	78%	78%	100%	100%	100%	100%
Spring Creek	82%	81%	100%	100%	92%	92%
Bergen Basin	50%	50%; 100%	67%	83%	58%	75%
Thurston Basin	60%	60% 100%	92%	100%	92%	100%
Paerdegat Basin	80%	89%	83%	100%	25%	75%

* At head of waterbody.

With these projects:

- Fresh Creek: CSO volume would be reduced by 61%. Total coliform criteria are projected to be 100% compliant and fecal coliform criteria are projected to be in attainment 83% of the time.

- Hendrix Creek: While CSOs to Hendrix Creek would increase, compliance with water quality standards would remain the same with 100% attainment for both total coliform and fecal coliforms.

- Spring Creek: Flows to Spring Creek will increase, but will be treated at the Spring Creek AWPCP, which removes floatables and solids. One hundred percent of total suspended solids and BOD are captured from flows that do not escape the facility. Thus total and fecal coliform criteria are projected to remain at 100% and 92% attainment, respectively.

- Bergen Basin: CSO volume would be reduced by 40%. With the CSO reduction in Bergin Basin, total coliform criteria are projected to be 83% compliant and fecal coliform criteria are projected to be in attainment 75% of the time. Total and fecal coliform standards would be achieved 100% of the time in the middle and mouth even though the head end does not achieve 100% attainment.

- Thurston Basin: CSO volume would be reduced by 87%. With the CSO reduction in Thurston Basin, total and fecal coliform criteria are projected to be met 100% of the time.

- Paerdegat Basin: With the construction of the CSO Retention Facility, 62% of potential CSOs would be directed to the WPCP for full treatment, while 35% would receive primary treatment at the facility. With this facility, total coliform should be in compliance 100% of the time and fecal coliforms would be in compliance 75% of the time.

Technical
These projects are technically feasible and, in fact, Spring Creek AWPCP has already been upgraded while Paerdegat is under construction. HLSS and sewer separation are difficult because they involve extensive sewer reconstruction within streets over large areas. During the drainage plan development for Southeast Queens, NYCDEP discovered deficiencies in the conveyance system that would compromise the HLSS if constructed without additional sewering. In-system overflows were detected that interconnect upstream storm sewers with combined sewers in Laurelton. The Southeast Queens Drainage Plan will address these technical issues and keep stormwater generated upstream of Laurelton isolated until it reaches Thurston Basin.

Cost
Costs for each of the projects are provided below under *Implementation Strategies*.

Legal
The projects discussed under this strategy are mandated under the CSO Consent Order and/or are part of the Waterbody/Watershed Plans submitted to NYSDEC pursuant to that order. For more information on the CSO Consent Order, please see Volume I, Chapter 3 (see Section 3.6), and "Water Quality."

RECOMMENDATION

NYCDEP will move forward with implementing measures under the CSO Consent Order and/or the WB/WS Plans. NYCDEP will also continue to evaluate other in-line and off-line infrastructure projects for potential inclusion in future plans as more data become available.

IMPLEMENTATION STRATEGIES

The implementation strategies listed here provide schedule and cost information for the programs discussed above. The Spring Creek AWPCP Upgrade was completed in April 2007 at a cost of $104.9 million. For additional information on these projects, please refer to the *Jamaica Bay and CSO Tributaries Waterbody/Watershed facility Plan and Paerdegat Basin LTCP*.

26th Ward 50 MGD Expansion

Increasing the treatment plant's wet weather capacity from 170 MGD to 220 MGD involves the construction of new primary settling tanks, larger pumps, a new chlorine contact chamber, and other related items.

Cost: $468 million.

Schedule: Final Design was initiated in 2006 and design completion is anticipated in June 2010. Construction will begin in June 2011 and be completed in December 2015.

Hendrix Creek – Evaluating In-line Storage

As part of the LTCP development, further evaluation will be performed for a bending weir that would be placed on top of the existing concrete weir to increase in-line capture of CSO discharges. A hydraulic analysis will be performed to determine if there is a risk of flooding. The cost will be part of the LTCP analysis and will be available when the final plan is released in August 2012.

Paerdegat CSO Retention Facility

NYCDEP is constructing a retention facility in Paerdegat Basin. The 50 MGD facility will capture CSOs at the Paerdegat Basin outfall and provide settling and floatables removal from the influent. Once a storm event passes, the stored flow will be redirected to the Coney Island WPCP for treatment.

Cost: $318 million.

Schedule: The facility is currently under construction and will be completed in 2012.

Laurelton High Level Storm Sewers

Following development of the Southeast Queens Drainage Plan in January 2008, NYCDEP will develop an implementation plan for designing and constructing HLSS and other improvements in the Laurelton area. The steps that generally follow drainage plan development include assessment of priority sewer system construction needs in the area, design of sewers for the priority areas, and finally construction of these sewers.

Cost: Cost estimates have not been developed as of yet since the drainage plan is not complete.

Schedule: No time frames have yet been established for reconstruction of the sewers in this area. Once the drainage plan is completed in January 2008, construction time frames will be developed.

Inflow/Infiltration Study with Corrective Measures

An Inflow and Infiltration Study with corrective follow-up would identify and resolve sewer system anomalies from illegal connections and interim measures that could allow sanitary flow to enter a stormwater pipe or stormwater to enter a sanitary pipe. Identifying and correcting these anomalies will improve the integrity of the separate sewer system and improve end-of-pipe water quality.

Cost: $2 million/year for engineering and $5 million/year for corrective measures.

Schedule: No time frames have yet been established for a start date or the required length of time to complete the study and corrective measures.

Regulators in Bergen Basin

NYCDEP will construct a new 48-inch inverted siphon under the Belt Parkway, enlarge the orifice at Regulator #3, and automate Regulator #2 to address hydraulic limitations that constrict wet weather flow to the Jamaica treatment facility.

Cost: $14 million.

Schedule: Final Design was initiated in February 2005 and completed in November 2006. Construction will begin in late 2007 and completion is estimated for June 2010.

Complete Sewer Separation in the Rockaways

The sewers are largely separated, but approximately 2,500 acres of storm sewers remain to be built.

Cost: The total cost to install separate sewers throughout the Rockaways is anticipated to be approximately $500 million.

Schedule: To be determined.

Management Strategy 1b3: Provide sanitary sewage treatment service to the remaining un-sewered neighborhoods along margins of the Bay.

STRATEGY DESCRIPTION

NYCDEP is actively addressing the few remaining neighborhoods around Jamaica Bay that do not have public sewer service and use one of the following: under-performing septic systems, storage tanks that require frequent pump-out, or illegal discharge into surface waters. NYCDEP is currently constructing stormwater and sanitary sewers in the Warnerville and Meadowmere sections of eastern Queens as well as undertaking a storm sewer and sanitary sewer project along the Jewel Streets in Howard Beach.

Warnerville / Meadowmere Sewer Project

This project will connect these neighborhoods to the Jamaica WPCP through a network of sanitary and storm sewers (see Figure 3.15). This project will connect these neighborhoods to the Jamaica WPCP through a network of sanitary and storm sewers (see Figure 3.15). Gravity sewers will bring flow from Meadowmere to the Warnerville pumping station that will direct the sanitary sewage to an existing sewer on 149th Avenue. Also included in this project is the creating and restoration of wetlands along Brookville Boulevard.

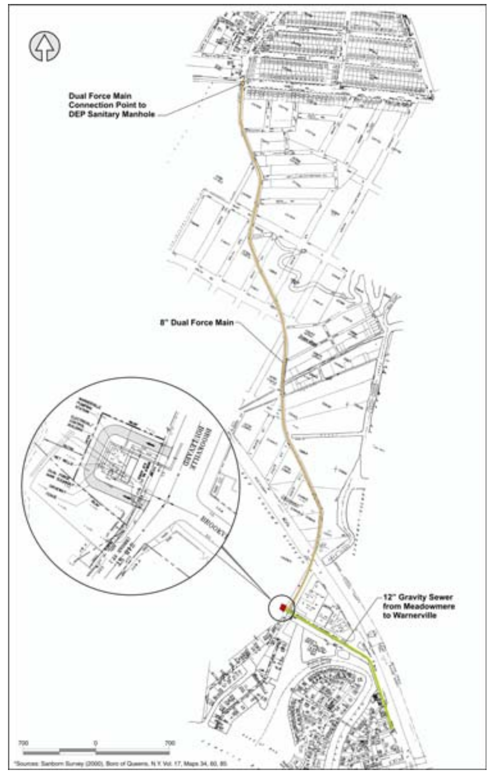


FIGURE 3.15 Meadowmere/Warneville Plan; Source: NYCDEP

Jewel Streets Sewer Project

NYCDEP is also undertaking a storm sewer and sanitary sewer project along the Jewel Streets (Ruby, Sapphire and Amber Streets) that straddle Brooklyn and Queens. The area has been plagued by flooding and failing septic systems respectively due to a lack of sanitary sewers and its topographical location in a low-lying "bowl" that can be eight feet lower than the surrounding community. The streets will be re-graded to allow adequate space for conveyance. This project also entails separating storm and sanitary sewers to prevent more CSO events. Stormwater will be treated using constructed wetlands with stilling basins as has been done in the Bluebelt Project in Staten Island. Other possible sites for constructing these stormwater treatment wetlands are Springfield Lake and Baisley Pond (see Management Strategy 3b4 for more information).

EVALUATION OF MANAGEMENT STRATEGY

This strategy would have a positive environmental impact by eliminating dry weather discharges to Mill Creek and Creek near Thurston Basin. There are no significant technical or legal obstacles to its implementation. While technically feasible, sewer construction involves extensive street work over large areas and is resource intensive. Costs are discussed below under the specific Implementation Strategies.

RECOMMENDATION

NYCDEP will continue to complete its planned projects to bring sanitary and storm sewers to currently unsewered areas**.**

IMPLEMENATION STRATEGIES

Warnerville / Meadowmere Sewer Project

NYCDEP has completed the design of sanitary sewers, a pump station, and a force main to collect this sanitary sewage and deliver it to the Jamaica WPCP for treatment. Much of the piping has already been laid and the construction of the pumping station has begun.

Cost: $30 million.

Schedule: This project is currently in construction with a construction completion date of March 2009.

Jewel Streets Sewer Project

NYCDEP will construct sanitary and storm sewers along with improved water mains for the Jewel Streets. The project would connect storm sewers to a stilling basin before discharging to a Jamaica Bay tributary. Along with sewer work, New York City Department of Transportation (NYCDOT) will reconstruct and re-grade the streets to create better drainage. Figure 3.16 illustrates the area around the Jewel Streets where construction would create a stilling basin at the top of a tidal creek and an existing siphon to treat stormwater.

Cost: $26 million from NYCDEP and $15 million from NYCDOT.

Schedule: This project is currently in design with a construction slated to begin in 2011.

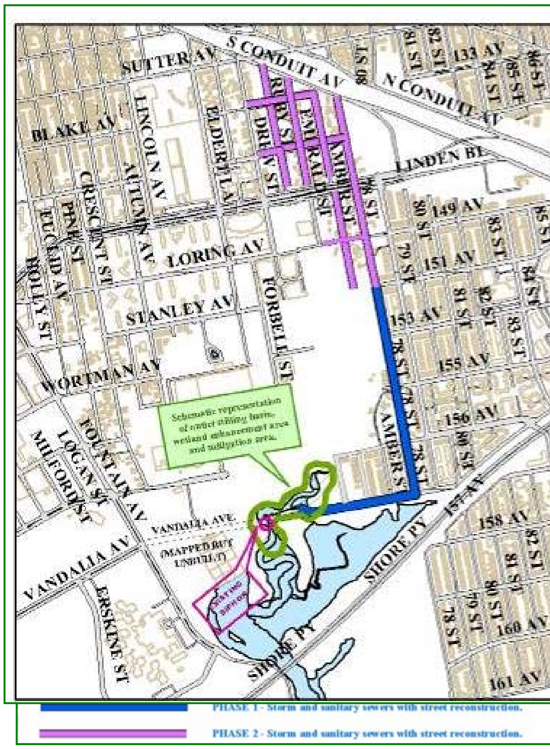


FIGURE 3.16 NYCDEP Jewel Streets Plan; Source: NYCDEP

Management Strategy 1b4: Expand boat pumpout program in Jamaica Bay.

STRATEGY DESCRIPTION

Under the Clean Vessel Act of 1992, the U.S. Department of Interior, Fish and Wildlife Service (USFWS), began a program to assist in reducing marine vessel waste in United States waterbodies. New York State's Clean Vessel Assistance Program (CVAP) was established to protect and improve water quality in New York's navigable waterways. The program provides federally funded grants of up to 75% of eligible project costs with a current maximum of $35,000 per project. The grants are to assist marinas, municipalities, and not-for-profit organizations install pump-out stations.

Paerdegat Basin Pump-Out.
Source: NYCDEP

To help improve water quality and provide an important free service to local area boaters, using matching funds from this program, NYCDEP has installed two pump-out facilities on Jamaica Bay. A boat pump-out unit installed in 2000 is located at the Coney Island WPCP, and a unit installed in 2005 is located at the Hudson River Yacht Club (Paerdegat Basin).

Paerdegat Basin Boat Pump-Out 1.
Source: NYCDEP

NYCDEP is currently developing the designs for a third facility at the Rockaway WPCP and obtaining required NYSDEC permits. NYCDEP expects to have this facility in operation for the 2008 boating season. Around the New York Harbor region, NYCDEP has installed seven pump-out facilities to help improve water quality in other waterbodies.

In addition to NYCDEP's free boat pump-out services, since 1994, the New York/New Jersey Baykeeper has operated a pump-out boat which travels to Jamaica Bay and offers free wastewater disposal to private boat owners. The pump-out boat discharges the wastewater at the Coney Island WPCP pump-out facility for treatment. Expansion of this type of program would encourage greater public use and reduce the amount of pathogens discharged from boat wastewater into Jamaica Bay. Funding from the CVAP is open to all marinas and environmental organizations, and NYCDEP encourages the wider use of this program by local marinas. Other municipalities, such as in Nassau and Suffolk Counties on Long Island, require pump-out units at marinas or facilities selling or dispensing gasoline. A similar effort within New York City would provide greater geographic coverage and use of boat pump-out facilities. Table 3.10 shows the location information for Boat Pump-outs in Jamaica Bay.

TABLE 3.10. Location Information For Boat Pump-Outs

Location	Longitude	Latitude
Hudson River Yacht Club	40.37.33	73.54.21
Coney Island WPCP	40.35.44	73.55.87

No Discharge Zone

As per existing legislation, before a waterbody can be considered eligible for a "no discharge zone" designation from the USEPA, a sufficient number (> 4) of pump-out units must be available for public use and they must be geographically spaced to service approximately 300 to 600 boats per boat pump-out unit (USEPA). It is estimated that approximately 1,200 boats are registered with marinas along Jamaica Bay (CVAP, 1996). Currently, within the City, the only waterway designated as a "no discharge zone" is the Hudson River from the Battery up to the Westchester County line. Along this stretch of the Hudson River, it is illegal for boaters to discharge sewage into local waterbodies. Therefore, additional sites for pump-outs beyond those already installed by NYCDEP will greatly assist in meeting these minimum requirements for a "no discharge zone" for Jamaica Bay.

EVALUATION OF MANAGEMENT STRATEGY

Environmental
The installation of additional boat pump-out facilities is a necessary component of a comprehensive program to reduce pathogens and other pollutants from entering Jamaica Bay and its tributaries.
.

Technical
A key factor in determining locations for additional pump-out facilities is proximity to a sanitary sewage line not located within a combined sewer area. In combined areas, underground storage tanks must be installed. The installation of these tanks significantly raises operation and maintenance costs through the regular emptying of the tanks. To avoid these additional costs, the Coney Island WPCP facility is directly fed to the wastewater stream at the plant and provides the most efficient operation. The other facility within Jamaica Bay and others located around the harbor have underground storage tanks that NYCDEP maintains on a regular basis. Depending on weather and boating traffic, these tanks need to be emptied up to three times a week from Memorial Day through Labor Day, the official operating time of the boat pump-out facilities. This significantly raises O&M costs of the boat pump-out units, particularly for smaller marinas. To help with these additional costs, mariana operators can obtain assistance is through the CVAP to pay for O&M costs (see below).

Legal
In addition to the boat pump-out unit, all facilities will require the installation of floating docks. The installation of floating docks does require NYSDEC and USACE review and permits. In situations where the existing pier fendering system does not allow a safe connection of the floating dock, several piles will need to be driven. This requires a more detailed review and permitting process.

Cost

Boat pump-out units:	$10,000
Installation:	$3,500
Purchase and installation of floating dock with piles:	$8,000

The Clean Vessel Act will reimburse 75% of the purchase and construction of the project for a maximum of $35,000. In addition to construction reimbursement costs, "an O&M Grant Program is available to provide recipients of CVAP grants with funding to assist in the annual costs of upkeep of the pump out. The CVAP O&M is intended for routine replacement items and costs incurred annually and not for major repairs. Funding is available for up to 75% of eligible costs with a maximum annual grant amount of $2,000 for pump out facilities" (CVAP 2007).

RECOMMENDATION

NYCDEP will install a third boat pump-out at the Rockaway WPCP and pursue additional locations for future pump-out units in Jamaica Bay. As noted above, a minimum of four boat pump-out units is necessary to begin the process of designating Jamaica Bay as a "no discharge zone." See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Install a Third Boat Pump out Facility at the Rockaway WPCP

NYCDEP is currently developing the designs for a third facility at the Rockaway WPCP and obtaining required NYSDEC permits.

Schedule: NYCDEP expects to have this facility in operation for the 2008 boating season.

Cost: Approximately $21,500.

Pursue Adding Additional Boat Pump-outs in Jamaica Bay and Obtaining a No Discharge Designation for the Bay

NYCDEP will continue to explore potential additional locations for future boat pump-out locations and encourages existing marinas to apply for CVAP grants to off-set construction costs of the facilities. There are a number of private marinas in Jamaica Bay that have the potential to install and operate a boat pump-out facility. NYCDEP will coordinate with these marinas and with Going Coastal, a nonprofit, educational and publishing organization focused on raising awareness of the coast's value and the importance of stewardship, to promote additional boat pump-out facilities. Interested marinas should contact:

CLEAN VESSEL ACT PUMPOUT GRANT PROGRAM
NYS Environmental Facilities Corporation
Technical Advisory Services
625 Broadway
Albany, New York 11207-2997
Attn: CVAP

Once the necessary pump-out facilities have been installed, NYCDEP will initiate the No Discharge Zone process. Under this process, NYSDEC must make a request to the USEPA that a particular area would like to be designated a “no discharge zone.” If designated, it will be illegal for boaters to discharge sewage to Jamaica Bay.

Schedule: To be determined.

Cost: Approximately $21,500. The Clean Vessel Act will reimburse 75% of the purchase and construction of the project for a maximum of $35,000. In addition to construction reimbursement costs, an O&M Grant Program is available to provide recipients of CVAP grants with funding to assist in the annual costs of upkeep of the pumpout.

OBJECTIVE 1C: INCREASE DISSOLVED OXYGEN LEVELS IN TRIBUTARY BASIN AREAS OF CHRONIC HYPOXIA TO IMPROVE ECOLOGICAL PRODUCTIVITY

INTRODUCTION AND ISSUES IDENTIFICATION

Deep areas in the tributaries of Jamaica Bay can lead to low DO concentrations in the water column. In deeper and wider areas of tributaries, current velocities slow down. These slower velocities allow particulate matter to settle and accumulate in the sediment where they can exert an sediment oxygen demand (SOD). In the deepest areas, due to temperature differences, density stratification can occur that reduces the vertical mixing of the water column. Due to this stratification, surface water that has higher DO concentrations cannot easily mix downward to bottom waters to replenish oxygen that has been lost due to SOD and the decomposition of organic matter in the water column.

To address these issues, the following two Management Strategies are discussed:

- Removal of CSO sediment mounds and/or re-contouring of tributaries to enhance drainage and eliminate borrow pits and deep trenches (Management Strategy 1c1)

- Determine hypoxic areas in the tributary basins that may benefit from mechanical aeration to increase DO concentrations (Management Strategy 1c2).

Current Programs

The Jamaica Bay WB/WS Plan recommends that that Hendrix Creek be dredged and recontoured. It also recommends that Fresh Creek, Bergen Basin, and Thurston Basin be dredged and recontoured and provided with aeration systems. The Paerdegat Basin LTCP recommended dredging but not aeration because the LTCP indicated that Paerdegat Basin might achieve the NYSDEC Class I DO standard of 4 mg/L; post-construction monitoring will confirm the attainment. These projects are discussed in more detail below. In addition, Shellbank Basin is currently implementing a pilot destratification system.

Management Strategy 1c1: Removal of CSO sediment mounds and/or re-contouring of tributaries to enhance drainage and eliminate borrow pits and deep trenches.

STRATEGY DESCRIPTION

CSO discharges include a combination of sanitary and stormwater flow and can contain high concentrations of solids. These solids over time have the potential to form large sediment mounds at the discharge point. The sediment mounds contain materials that increase BOD and have contaminants associated with sanitary flow and stormwater runoff that result in low DO levels in the water column, potential odor problems, and sediment that is toxic to aquatic life.

Some tributary basins in Jamaica Bay have deep pits from dredging and CSO scouring, along their lengths and at the head (away from Jamaica Bay) end of the basins; however, these become very shallow where the channel connects to Jamaica Bay. For example, Shellbank Basin has a depth of 52 feet at the head end, while the depth where it discharges to Jamaica Bay is only 7 feet. Mill and East Mill Basins, and Norton Basin, have similar bathymetric features. This atypical and unnatural bottom topography results in poor tidal circulation and the development of hypoxic or anoxic waters which can be transported into the near shore areas of Jamaica Bay during large storm events, when tidal surges greatly increase the circulation of waters in and out of these basins.

Different modeling analyses have indicated that re-contouring the non-CSO basins to a shallower depth, on the order of 6.0 to 10.0 ft, could eliminate the hypoxic conditions and improve DO concentrations.

CSO Impacted Tributaries

Sediment mounds are found in each of the CSO tributaries. These mounds contain settled CSO solids and in some basins settled stormwater solids. The CSO tributaries include Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin and Thurston Basin, although technically Spring Creek does not have a CSO because the flow passes through an auxiliary WPCP first for removal of the heaviest settleable solids. CSO mounds develop as particulate matter contained in the CSO flow settles down to the tributary sediment and accumulates over time. CSO mounds are a problem because they accumulate contaminants and result in a poor ecological habitat. They also exert a SOD that contributes to lower DO levels in the water column at the head ends of these CSO–impacted tributaries. If a CSO mound is removed, the tendency for the mound to reform will occur if the CSO discharge is not entirely eliminated. Therefore, the removal of a CSO mound can be viewed as an interim measure that needs to be performed on an as-needed basis. Reducing the quantity and improving the quality of the CSO flow will result in a decrease of CSO sediment building mounds and may have lower concentrations than the original mound. Proposed stormwater best management practices, WPCP upgrades and sewer cleaning improvements will also assist in reducing CSO volumes.

NYCDEP has made the commitment to dredge the CSO mounds in Paerdegat Basin, Fresh Creek, Hendrix Creek, Bergen Basin and Thurston Basin. These CSO mounds will be dredged to 5 feet below mean lower low water (MLLW) and then capped with 2 feet of clean material to bring the re-contoured bottom up to 3 feet below MLLW.

Under the Jamaica Bay Ecosystem Restoration Project (JBERP), of which NYCDEP is a local cost-share partner, the USACE developed plans to modify two of the tributaries, Paerdegat Basin and Fresh Creek, in order to improve DO levels and restore tidal marshes. To ensure that the removal of the CSO mounds provide the most ecological improvements, NYCDEP to the greatest extent possible, will coordinate and work with the regulatory agencies to form partnerships as appropriate so that the dredging of the CSO mounds can be combined with the ecological restoration plans proposed by the USACE and NYCDEP. For example, NYCDEP's recontouring projects will only be near the head ends of the basins over a distance of approximately 1,000 to 1,500 feet, and the recontouring of the remaining portions of the basins to depths of 6 feet below MLW would need to be coordinated with the USACE. Recontouring Paerdegat Basin and Fresh Creek to total depths on the order of 6 ft below mean lowwater (MLW) would improve water quality by enhancing vertical mixing and by enhancing the flushing of the basins with cleaner water from Jamaica Bay. The amount of water that would remain in the basin for long periods of time would be reduced. This would increase the tidal exchange between low water and high water for a much more effective flushing mechanism.

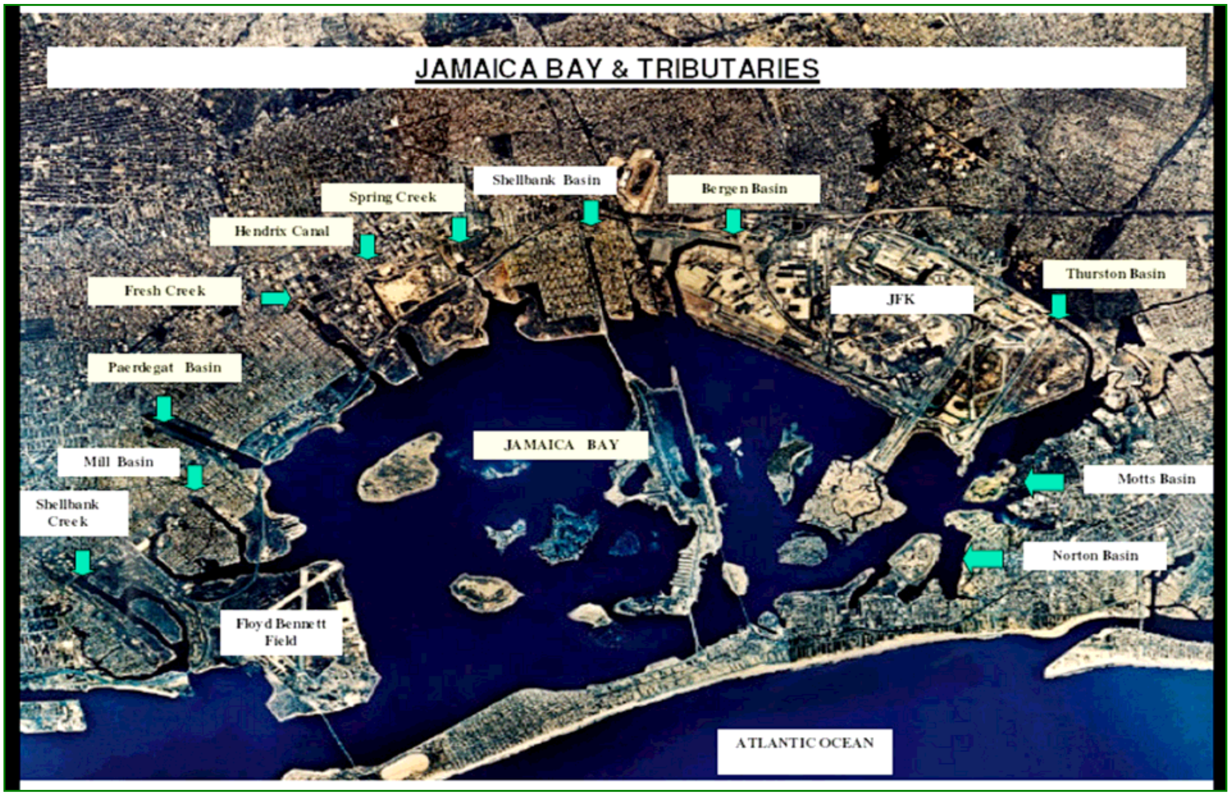


FIGURE 3.18 Tributaries of Jamaica Bay; Source: NYCDEP

NYCDEP is in the process of soliciting a consultant to develop the dredging designs and complete permit applications. It is anticipated that this dredging contract will be in-place in early 2009 so that dredging can be initiated in Paerdegat Basin as soon as the retention facility comes into service in 2011. NYCDEP through an existing contract has already developed a design for dredging of Hendrix Creek and will solicit a contractor to perform these dredging operations in early 2008.

Non-CSO Impacted Tributaries

Other areas that are known to have artificially deep basins that result in density stratification include Norton Basin, Shellbank Basin, and Mill Basin. The area of Norton Basin known as Little Bay has depths greater than 60 ft and experiences anoxia during much of the year. The USACE has proposed plans to re-contour the basin to a shallower depth, which have yet to be approved. Shellbank Basin is more than 50 ft deep at the head end and also experiences anoxia. A low energy diffuser destratification system is being used to mix the water column. The destratification increases the DO from 0.0 to 1.0 mg/L and prevents the system from stratifying (see Management Strategy 1c2 below). The increase in DO prevents the production of hydrogen sulfide to reduce odors, but it does little to improve aquatic habitat or meet water quality standards. Mill Basin is approximately 40 ft deep and experiences hypoxia and anoxia. The low DO concentration in Mill Basin is primarily due to SOD resulting from the deposition of organic matter from other sources such as stormwater and algal growth.

Some of the tributaries do not have sufficient data to determine if they suffer from poor water quality, or to assess whether they could benefit from re-contouring. For example, data from the Arverne

Environmental Impact Statement indicate that areas in Vernam, Sommerville and Barbadoes Basins experience at least occasional hypoxia (DO < 3.0 mg/L) (HPD 2003). Areas in Sommerville Basin are greater than 40 ft deep and Vernam Basin has areas that are greater than 30 ft deep. While Barbadoes Basin is only 10 to 15 ft deep, the entrance channel to the basin is constricted, based on the U.S. National Oceanic and Atmospheric Administration (NOAA) nautical chart for Jamaica Bay, and this may affect overall water quality. Currently, none of these basins have plans for water quality or habitat improvements.

However, if information from the other tributaries with data can be extrapolated, it appears likely that most of the tributaries could have periods with low DO levels. All of these tributaries could have improved bottom DO concentrations if they were made shallower. In general, the deeper the tributary the more likely it would benefit from re-contouring.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The removal and recontouring of the CSO mounds in affected tributary basins will improve water quality, reduce noxious odors, provide for more diverse and healthier benthic habitats and remove contaminated sediments (polynuclear aromatic hydrocarbons (PAHs), pesticides, etc.) that have been discharged from the CSO outfalls through the years. Different modeling analyses have indicated that re-contouring the tributary basins to a shallower depth could eliminate or reduce the hypoxic conditions and improve DO concentrations.

Technical

Dredging will need to be done in a manner that minimizes disturbance and potential environmental effects. Dredging can be done in colder months to minimize potential for odors.

Legal

Dredging and the recontouring of tributaries within Jamaica Bay will require dredging and tidal wetland construction permits from NYSDEC in coordination with the USACE. Permits or authorizations would be required from NYSDEC, USACE, National Marine Fisheries Service (NMFS), and perhaps others, including:

- 33 CFR 225 – USACE Dredged Material Permit
- 33 CFR 323 – Compliance with definition of "Fill Material" under Section 404 of Clean Water Act.
- Section 401 of the Clean Water Act (Water Quality Certification)

Costs

See *Implementation Strategies* below for cost information.

RECOMMENDATION

NYCDEP will pursue the dredging and recontouring of Hendrix Creek and in the future, Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Dredge and Recontour Hendrix Creek

Improving the water quality and reducing the noxious odors from CSO buildup, the dredging will remove approximately 20,000 cubic yards of accumulated sediment and include capping the bottom with a mixture of clean sand and gravel.

Schedule: Final design was initiated in January 207 and was completed in June 2007. Construction schedule is being developed.

Cost: To be determined.

Pursue Dredging of Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin

Implementation schedules for dredging and recontouring of Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin have been developed and submitted to NYSDEC for approval in the *Paerdegat Basin LTCP* report and the *Jamaica Bay and Tributaries Waterbody/Watershed Plan* report.

Schedule: To be determined.

Cost: To be determined.

Support JBERP in Paerdegat Basin and Fresh Creek

The JBERP program proposed by the USACE with the NYCDEP as the local cost-sharing partner for Paerdegat Basin and Fresh Creek would provide comprehensive habitat and ecological benefits. NYCDEP strongly recommends that the USACE secure funding to continue with these proposed restoration activities in Paerdegat Basin and Fresh Creek as well as other CSO and non-CSO tributaries in Jamaica Bay.

Schedule: To be determined.

Cost: To be determined.

Management Strategy 1c2: Determine hypoxic area in the tributary basins that may benefit from mechanical aeration to increase dissolved oxygen concentrations.

STRATEGY DESCRIPTION

Aeration of water is the supply of air to a water body. Coarse bubble diffuser aeration utilizes compressors to supply air and a network of pipes and diffusers located beneath the water surface to distribute the air. A standard coarse bubble diffuser system might consist of an air intake structure, compressors to transport the pressurized air through supply piping, the mains and headers to convey the air to its point of delivery and a network of diffusers. At the diffusers, the compressed air is released to the water column in the form of coarse bubbles. These bubbles rise to the water surface, transferring oxygen to the water as they rise.

Multistage centrifugal compressors, or rotary positive displacement units, are often used to achieve the airflow and pressure required. The compressors are designed to develop sufficient pressure to overcome static head and friction losses of the supply piping, while delivering air at the required flow rate to the diffuser network.

The projects recommended under the WB/WS Plan, as discussed in Management Strategy 1b2, does not bring Fresh Creek to 100 percent attainment of DO standards. A number of alternatives were considered, yet only in-stream aeration was shown to affect DO compliance. NYCDEP is currently constructing an aeration pilot in Newtown Creek to analyze the effects of aeration in the New York Harbor. Results from this pilot will inform decisions made in Jamaica Bay. Aeration strategies used in other locations have also been evaluated according to their ability to improve DO and minimize ecological impacts associated with the installation and operation of aeration systems.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The major factors affecting the dissolved oxygen levels in Jamaica Bay tributaries include the existing bathymetry of the tributary; whether there are discharges of stormwater, CSO, or WPCPs; the existing organic layer on the bottom of the tributary; and the interface of the substrate (bottom materials) with the waters of respective tributaries. It is important that these factors be taken into consideration in the determination of the oxygen input required to maintain a minimum dissolved oxygen level that meets the current NYSDEC dissolved oxygen water quality standard. Weather, temperature, tidal activity and a number of other variables also play an important part in the DO levels.

Over the years, significant sampling, analysis and water quality modeling have been performed on Jamaica Bay. However, there is less data on the condition of the tributaries. The WB/WS Plan provided water quality modeling for the CSO tributaries as shown in Table 3.11[1], based on 1988 data. Fresh Creek would meet DO levels 72% of the time with the WB/WS Plan and 100% if aeration is implemented. In Bergen Basin, DO levels would be met 100% of the time if aeration is implemented and only 50% without aeration. Similarly, Thurston Basin would also meet DO compliance levels 100% of the time with aeration, but only 60% without aeration.

TABLE 3.11. Annual DO Compliance Levels

Tributary	*Baseline*	*Future without Aeration*	*Future with Aeration*
Fresh Creek	60%	72%	100%
Bergen Basin	50%	50%	100%
Thurston Basin	60%	60%	100%
*At head of waterbody			

[1] The CSO tributaries of Jamaica Bay are: Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin.

Further, the results of the North Channel Model, a subset of the peer-reviewed JEM model, and used for the WB/WS Plan, may be indicative of locations of hypoxia in the tributaries. This, taken together with citizen odor complaints, is helpful to refine the selection of tributaries to receive treatment. Sampling and analysis would confirm hypoxic locations.

Technical

A coarse bubble diffused aeration system for Jamaica Bay tributaries has advantages as well as disadvantages. The advantage of coarse bubble diffusion aeration is that it is a proven aeration system used in many wastewater treatment systems and has been used in the Cardiff Bay Project to improve dissolved oxygen within the fabricated escarpment. The Cardiff Bay project required the use of supplemental oxygen injected by spargers mounted on a barge with liquid oxygen tank (LOX) storage tank. This may not be the case in the Jamaica Bay tributaries as they are much shallower then Cardiff Bay. Typically, these systems are relatively easy to operate once installed, with all mechanical parts located on shore for ease of repair and maintenance. The disadvantages of coarse bubble diffusers are the difficulty of installation as well as inspection and maintenance of the system.

If the tributary does not have at least six feet of freeboard (distance from bottom to MLW, the aeration system is not efficient at transferring oxygen, and the tributary needs to be dredged to minus six feet below MLW. Dredging removes the settled CSO solids from the bottom of waterbodies. This restricts the area where the solids settle out and allows the waterbody to retain readily settleable solids that are carried by CSO discharges. The settled solids would be dredged from the receiving waterbody as needed to prevent use impairments such as nuisance odor conditions. Monitoring the need for dredging periodically to prevent the use impairment/nuisance conditions from occurring is essential. Dredging would be conducted as an alternative to structural CSO controls such as storage. Bottom water conditions between dredging operations would likely not comply with dissolved oxygen standards and bottom habitat would degrade following each dredging. In this case, dredging is needed to bring the bottom to minus six feet below MLW to increase the effectiveness of the aeration system. If the material to be dredged form each tributary is a Class C material, as defined within NYSDEC Technical & Operational Guidance Series (TOGS) 5.1.9, it would need to be removed and a clean sand cap provided. Dredging would be to eight feet below MLW and then capped with two feet of clean sand.

Two other technical issues include:

- Costs and effectiveness of DO transfer – The size of the system would be decided based on water quality modeling of the respective tributaries. Modeling the DO requirements of a tidal basin or creek is difficult with the possibility that an installed system may be undersized for the need. This happened to a system installed in Cardiff, Bay, Wales, UK. During periods of low flow, high temperatures and low wind velocity, the DO concentration was not in attainment with the water quality standard. The Environmental Agency required Cardiff Bay authorities to inject liquid oxygen through a side stream so that the DO water quality standard could be achieved.

- Effect on the environment – Hypersaturation of air in the waters of the tributaries may be harmful to aquatic organisms. The diffusers must be correctly spaced to prevent suspension of benthic material and appropriate mixing of the diffused air to occur.

Legal

Aeration and potential dredging for aeration of tributaries within Jamaica Bay will require dredging and tidal wetlands construction permits from the NYSDEC in coordination with the USACE. Permits or authorizations would be required from NYSDEC, USACE, NMFS, and perhaps others, including:

- 33 CFR 225 – USACE Dredged Material Permit
- 33 CFR 323 – Compliance with definition of "Fill Material" under Section 404 of Clean Water Act.
- Section 401 of the Clean Water Act (Water Quality Certification).

Costs

For initial cost estimates for Fresh Creek, Bergin and Thurston Basins, see Implementation Strategies below. Costs cannot be determined for those tributaries that have limited water quality and sediment data. The dredging and aeration costs would be site specific to each tributary.

RECOMMENDATION

NYCDEP will pursue the dredging and aeration of Fresh Creek, Bergen Basin and Thurston Basin. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Pursue In-stream Aeration for Bergen and Thurston Basins

Increasing the DO levels in Bergen and Thurston Basins can be attained by adding in-stream aeration. Dredging each waterbody will be part of in-stream aeration to create a water column deep enough to achieve adequate oxygen transfer through the full range of tidal exchange.

Cost: Approximately $112 million.

Schedule: Installation of in-stream aeration would be subject to successful completion of the Newtown Creek demonstration project and permitting at the facilities. Final Design is estimated to begin in 2015 and finish in 2017. Construction is slated to begin in 2018 and completion is estimated for 2021.

Pursue In-stream Aeration for Fresh Creek

Increasing the DO levels in Fresh Creek can be attained by adding in-stream aeration. Dredging Fresh Creek will be part of in-stream aeration to create a water column deep enough to achieve adequate oxygen transfer through the full range of tidal exchange.

Cost: $82 million.

Schedule: Installation of in-stream aeration would be subject to successful completion of the Newtown Creek demonstration project and permitting at the facilities. Final Design is estimated to begin in 2015 and finish in 2017. Construction is slated to begin in 2018 and completion is estimated for 2021.

Investigate Potential for Future Aeration in Other CSO and Non-CSO Tributaries

For the other CSO and non-CSO tributaries, the following are the needs to be estimated, and steps in the process:

- Review literature and studies to evaluate potential tributaries that may be hypoxic.
- Water quality modeling performed for both the CJBWQP and the WB/WS Plan indicate that the following tributaries may be hypoxic and were preliminarily ranked with the most likely to be stratified first:
    - East Mill Basin
    - Mill Basin
    - Sheepshead Bay
    - Hawtree Basin.
- Review citizen complaints related to odor at specific tributaries.
- Collect data in tributaries where data are lacking to verify hypoxia.
- Perform water quality modeling data plots to determine ranking of creeks/basins.
- Determine if aeration for the basin/creek is for destratification or attaining WQS.
- Select a DO goal for each basin/creek selected.
- Determine if creek/basin needs dredging for the aeration system to perform.
- Select Basins and a schedule to implement.

Schedule: To be determined.

Cost: To be determined.

OBJECTIVE 1D: DEVELOP A ROBUST AND COORDINATE SCIENTIFIC PROGRAM

Current Programs

New York Harbor waters are cleaner now than at any time in the last 50 years. The water quality within Jamaica Bay has significantly improved and the continued improvements by NYCDEP to the wastewater treatment handling and treatment are chiefly responsible for continued improvements to water quality, which have led to increased recreational opportunities. New York City was one of the first metropolitan areas in the United States to design, construct and operate a modern sewage treatment facility. Portions of the Harbor Waters have been monitored for water quality since 1909 nearly 100 years of data collection. Research by NYCDEP has clearly shown that the waters around the City and Jamaica Bay are healthier than they have been since the beginning of the 20^{th} century.

In order to develop an effective scientific monitoring program, the goals of the program must first be defined. For example, the NYCDEP water quality sampling program for Jamaica Bay grew from one of the oldest and continuous monitoring programs in the United States, the Harbor Survey Program. The goal of this program is to monitor the general health of the harbor waters to determine the quality of the waters through the effectiveness of the WPCP upgrades and other environmental measures implemented by NYCDEP. As such, the City's current monitoring program for Jamaica Bay focuses on monitoring the general trends in water quality over time.

Jamaica Bay has been extensively studied over a range of many disciplines and by a wide range of entities including the efforts of NYCDEP, the NPS, NYSDEC, the USACE, and various academic programs. These studies have included a review of important vegetation communities, wildlife use, sediment deposition rates, sea level rise, wetland losses, nitrogen discharges, atmospheric deposition rates and sediment toxicity. This list of topics is not meant to imply an exhaustive list of research efforts but rather to illustrate that the Bay has had extensive study over the years covering many topics, but not necessarily in a coordinated effort that informs other studies with critical information.

To date, the monitoring efforts of water quality improvements within Jamaica Bay have primarily focused on tracking the following areas:

- Reduction of nitrogen loadings to the Bay;
- Reduction of CSO pathogen loadings to the Bay; and
- Improvement of the Bay ecosystem.

CURRENT NYCDEP MONITORING

NYCDEP Harbor Water Quality Survey In Jamaica Bay

There are currently eight open water sampling stations in Jamaica Bay and one located in Sheepshead Bay (see Figure 3.18, Active Harbor Survey Stations, below). The stations generally provide good spatial coverage of the Bay. However, one area that is not currently sampled is the center of the Bay within the intertidal marshes where shallow water depth makes sampling logistically difficult. The tributaries are sampled on a non-structured rotating basis.

Several parameters (salinity, temperature, pH, and DO) are sampled at both the surface and bottom. The nutrient series, chlorophyll, fecal coliforms and enterococci are sampled at the surface. The majority of the Bay is well mixed vertically, and additional bottom sampling is likely not to be warranted.

The majority of the sampling completed by NYCDEP is discrete sampling on a weekly to monthly basis at one particular location. These samples provide snapshots of water quality and can miss short-term or localized events. Continuous monitors can provide information on a more frequent basis, which allows the observation of short-term events, such as meteorological events, and tide cycles. Currently, NYCDEP has two continuous monitors in Jamaica Bay. One is located at Kingsborough College in Sheepshead Bay and the other is located on Broad Channel. These locations were chosen because they are in accessible, secure locations. The meters measure water level, temperature, salinity, dissolved oxygen, and chlorophyll, as well as meteorological information. However, the information from these monitoring stations is somewhat limited because they do not represent the open waters of the Bay.

As part of the CJBWQP, a series of short duration but multiple year ecosystem studies have been conducted. The study includes two moorings that have near surface and near bottom continuous monitors, and were deployed in North Channel and Grassy Bay. These monitors include temperature, salinity, and DO sensors

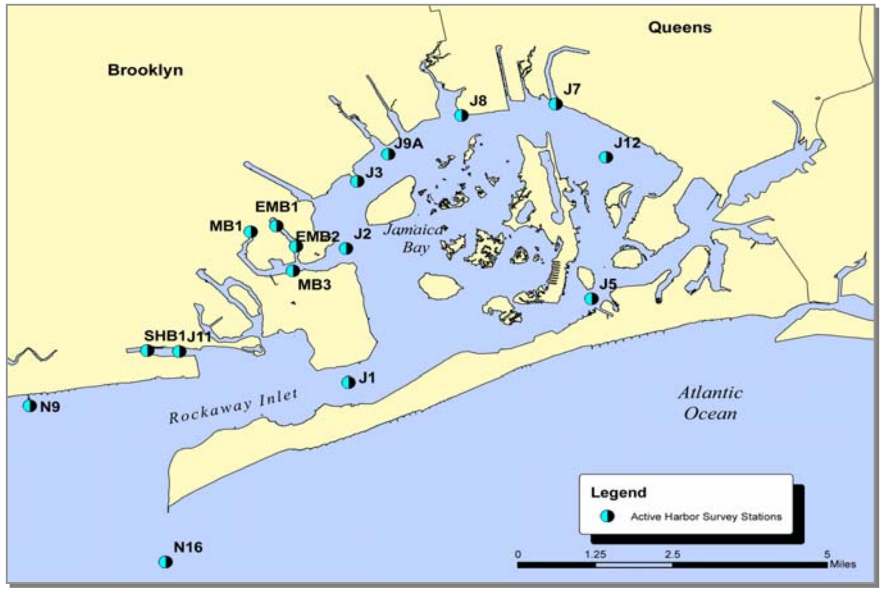


FIGURE 3.18 Active Harbor Water Survey Stations: HydroQual

BIOLOGICAL MONITORING

As part of the Jamaica Bay ecosystem studies being conducted under the CJBWQP project, short term biological monitoring is also being conducted. This sampling enhances the understanding of the relationship between dissolved oxygen and unionized ammonia concentrations and the health of the ecosystem. As part of the studies, sediment profile imaging (SPI) is being used to assess the quality of the benthic community. The images allow the observation of benthic organisms, the depth of the aerobic sediment layer, and the existence of hydrogen sulfide bubbles in the sediment. Benthic sampling was also conducted to complete species identification and enumeration. In the water column, trawls were conducted to collect fish eggs and larvae. Species identification and enumeration was conducted on these samples. Some samples were tested for RNA:DNA ratios to determine if there was evidence of stress on the growth of the organisms. This monitoring is part of a short term study over several years and is expected to continue through June 2008.

WPCP EFFLUENT SAMPLING

NYCDEP, as part of the SPDES permit monitoring, conducts extensive sampling of the effluent discharges (flow and pollutants) from the four WPCPs discharging to Jamaica Bay. The results of these sampling activities are reported to the NYSDEC monthly.

CSO AND STORMWATER SAMPLING

Samples of combined sewer overflows and stormwater collected from outfalls to Jamaica Bay and its tributaries have all been associated with CSO planning projects. For example, between 1985 and 2005 thousands of samples of CSO and stormwater quality samples have been collected by the NYCDEP. Further some limited flow monitoring has been conducted as part of these projects. There are currently no programs to monitor CSO or stormwater flow or quality in a way similar to the SPDES-required WPCP effluent monitoring. However, with the completion of the Waterbody/Watershed planning portion of the Long Term Control Plan, NYCDEP will be receiving modifications from NYSDEC to SPDES permits for the Coney Island WPCP and the 26th Ward WPCP for CSO facilities that now discharge or in the future will discharge to Jamaica Bay tributaries (Paerdegat Basin CSO Retention facility and the Spring Creek CSO Retention facility). These permits will require sampling and reporting of the treated effluent (flow and quality). NYCDEP will be required at that point to initiate a sampling program for those CSO facilities.

Management Strategy 1d1: Identify potential additional monitoring needs and develop an enhanced monitoring program.

STRATEGY DESCRIPTION

NYCDEP reviewed its current monitoring programs as well as programs in place in other harbor estuary areas to identify potential additional monitoring needs. The goal of any enhanced monitoring of Jamaica Bay would be to evaluate on a scientific basis the effectiveness of strategies and measures implemented under the Jamaica Bay Watershed Protection Plan and other efforts.

In addition to identifying additional monitoring, a coordinated collaborative effort between academic and public agency research efforts is necessary to develop a comprehensive sampling program and identify data gaps and issues that require further analysis. A central clearinghouse for data is essential to keep other research informed; much research has been done, but the data is located in diffuse locations and not easily coordinated to determine possible linkages between research efforts or findings.

Table 3.12 presents a comparison of the NYCDEP Harbor Water Quality Survey to other monitoring programs around the country. The programs include monitoring programs for Chesapeake Bay, Massachusetts Bay (Massachusetts Water Resources Authority (MWRA)), Chicago (Lake Michigan), South Florida (Southeast Environmental Research Center), Port of San Diego, Port of Los Angeles, and the National Estuarine Research Reserve System (NERR) of NOAA. The size of the programs depends on the goals and available funding. The California ports have small sampling programs. Chicago's program is concerned with the use of Lake Michigan as drinking water. The MWRA program is monitoring the impact of a newly relocated treatment plant effluent outfall on a large ecosystem. The Chesapeake Bay program attempts to look at the entire ecosystem. Each of these programs bring a unique perspective on monitoring efforts. In general, the NYCDEP Harbor Survey Program falls somewhere in the middle of these other programs for water quality and sediment monitoring. The water quality sampling is among the most comprehensive of those reviewed, but falls a little short of the MWRA and Chesapeake Bay programs.

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Stations	9	32	93	27	80	100+	5	31	
	Frequency per year	24	12 – 16	12 – 20	6 – 12	5	4 – 12	Buoys	12	12
	Depth	S/B			S/BV	S				B
	Temperature	X	X	X	X		X	X	X	X
	Salinity	X	X		X		X	X		X
	Dissolved Oxygen	X	X	X	X		X	X	X	X
	BOD								X	
	Specific conductance		X	X				X		
	pH	X	X	X						X
	Secchi Depth	X	X	X			X			
	Light Attenuation/PAR		X	X	X					
	Turbidity						X	X		
	Orthophosphate	X	X	X	X		X			X
	Total Dissolved Phosphate		X	X	X					X
	Particulate phosphate		X	X	X					
	Total Phosphorus	X					X			
	Nitrite		X	X						
	Nitrite+nitrate	X	X	X	X		X			X
	Ammonium	X	X	X	X		X			X
	Total dissolved nitrogen		X	X	X					
	Particulate nitrogen		X	X	X					

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Total organic nitrogen						X			
	Total Kjeldahl nitrogen	X								
	Total nitrogen						X			
	Dissolved organic carbon	X								
	Dissolved inorganic carbon				X					
	Particulate carbon		X	X						
	Total organic carbon						X			
	Dissolved silica	X	X	X	X		X			
	Biogenic silica				X					
	Total suspended solids	X	X		X					
	Volatile suspended solids		X	X						
	Chlorophyll-a	X	X	X		X	X			X
	Pheophytin		X	X						
	Fluorescence			X	X					
	Colored dissolved organic matter		X							
	Alkaline Phosphates Activity						X			
	Odor and color							X		
	Oil and grease							X		
	Floating solids				X			X		
	Cyanide					X				

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Metals					X				
	Pesticides					X				
	Total coliforms					X				
	Fecal coliforms	X				X				
	Enterococcus	X								
Sediment	Stations				8+					
	Frequency		4	4	1					
	Sediment analysis		X	X						
	Percent dry weight				X					
	Total organic carbon				X					
	Metals				X					
	PCBs				X					
	PAHs				X					
	Pesticides				X					
	Grain size				X					
Sediment	*Clostridium perfringens*				X					
	SPI		X		X					
Plankton	Stations									
	Frequency									
	Phytoplankton identification		X	X	X					
	Phytoplankton abundance		X	X	X					
	Picoplankton		X							

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Mesozooplankton		X	X	X					
	Microzooplankton		X	X	X					
	Primary Production		X	X	X					
Benthos	Stations									
	Frequency									
	Benthic fauna identification		X	X						
	Benthic fauna counts		X	X						
	Benthic fauna biomass		X	X						
Fisheries	Stations									
	Frequency			1						
	Trawl and seine			X						
	Fish samples				X	X				
SAV				X						
Remote Sensing				X	X					

Based on this review, the addition of more water quality parameters, sediment sampling, and the sampling of aquatic and benthic biota similar to those of other estuary programs is required to better assess the holistic health of the Jamaica Bay ecosystem. The addition of more frequent water/sediment quality sampling and locations within the Bay, as well as monitoring efforts within the upland portions of the watershed would be required. For many areas and in particular the upland portions of the watershed, multiple entities forming collaborative partnerships to collect and process monitoring data would need to be part of a comprehensive plan.

To begin to collect additional data, the following potential water quality parameter monitoring enhancements could be added to NYCDEP's current sampling efforts.

Potential Water Quality Parameters

The following parameters could be part of an enhanced program:

- particulate organic carbon
- particulate organic nitrogen
- particulate organic phosphorus
- biogenic silica
- dissolved organic carbon
- dissolved organic nitrogen
- dissolved organic phosphorus.

These constituents provide additional information on phytoplankton in the Bay, which is very useful in assessing the eutrophic nature of the system. Additionally, phytoplankton enumeration and species identification would provide useful information on the Jamaica Bay ecosystem. Samples for these parameters could be collected from within the Bay at the same frequency as NYCDEP's routine monitoring is conducted.

As discussed above, under the Comprehensive Jamaica Bay Water Quality Plan, two moorings with near surface and near bottom continuous monitors were deployed in North Channel and Grassy Bay. These monitors include temperature, salinity, and DO sensors. A recommendation has been made to add an additional mooring station in Broad Channel.

Another monitoring need is an area not currently sampled - the center of the Bay within the intertidal marshes where shallow water depth makes sampling logistically difficult. An additional water quality sampling station within the center of the Bay and more regular sampling at select tributary locations will give a better indication of the ecological integrity and function of the system.

To date, NYCDEP has avoided deploying monitoring buoys in the open waters for several reasons. The buoys required for this monitoring are large, too large for NYCDEP to deploy using its current boats. When buoys such as these are deployed, there is a tendency for boaters to dock off the buoys, which can cause damage to the monitoring equipment. Theft of equipment is also a concern. Further, Jamaica Bay is very productive in terms of algae growth, so monitoring equipment can become biofouled within weeks, and require considerable maintenance.

As noted above, NYCDEP will conduct additional water quality monitoring of the CSO tributaries as part of its Long Term Control Plan. A sampling plan will be developed and approved by the

NYSDEC prior to the initiation of routine monitoring of the CSO impacted tributaries. CSO facility discharges – including the Paerdegat CSO retention facility, which is under construction, and the Spring Creek AWPCP CSO retention facility – will also be monitored.

As discussed under Chapter 5, Stormwater Best Management Practices, CSO volumes and discharges will also be monitored to assess the effectiveness of stormwater BMPs and other land use strategies as they are implemented over time.

ADDITIONAL ENHANCED MONITORING (would need to be in collaboration with other agencies)

Potential Sediment Sampling

A significant modification to the current sampling program could be the inclusion of sediment sampling. Sediment nutrient flux measurements, sediment oxygen demand, pore water and solid phase measurements will be added to the program on a limited basis. Both the Chesapeake Bay and Massachusetts Bay (MWRA) programs include limited sediment sampling. This type of sampling and analysis is highly specialized and would have to be completed by laboratories and researchers outside of NYCDEP, potentially in partnership with other agencies and academic institutions.

Potential Biological Sampling

The aforementioned sampling focuses on water quality indicators, which does not necessarily present a clear picture of the health of the ecosystem. Biological sampling will be conducted to provide this information. NYCDEP could institute biological sampling to include parameters such as algae enumeration and identification, SAV, as well as biological indicators such as benthic diversity.

Salt Marsh Island Monitoring

In addition, salt marsh island monitoring needs to be continued and expanded to include continued monitoring of wetland biomass production; extent of marsh coverage from year to year; wetland elevation monitoring; and sediment sampling within marsh

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Increasing the diversity and scope of the environmental sampling parameters will provide a better understanding of how the ecosystem of Jamaica Bay is functioning and the potential effects from changing environmental variables (*e.g.*, nutrient loading, temperature, wind, etc.). Additional water quality constituents within a comprehensive sampling program will assist in the further understanding of the health of the Bay as it relates to eutrophic conditions. In order to provide effective and useful data, water quality and ecosystem monitoring must be done in a coordinated fashion and be capable of informing other research efforts.

The JBWPP strategies target improvements in various aspects of the water quality of Jamaica Bay. An enhanced sampling program should be tailored to tracking the effectiveness of these changes as they are implemented over time. With this understanding, these measures can be refined and improved through adaptive management or other measures developed for further enhancements to the environmental quality of Jamaica Bay.

Technical
In order to be most effective, monitoring programs should be coordinated among the various entities. In order for the data collected by different entities to be useful in aggregate, the various entities must use similar protocols and collection methods. To achieve this, it is important that the various existing monitoring programs be coordinated through a central clearinghouse.

Cost

TABLE 3.13 Water Quality Sampling Costs

Sampling Type	Cost	Measurement Unit	Sampling Frequency
Sediment Profile Imagery	$43,000	50 stations	2x/year
Pore Water	$36,000	12 stations	2x/year
Benthic Habitat	$66,000	42 stations	2x/year
Moored Water Quality Sensors	$21,000	3 sensors/month	continuous
Mobile WQ Sampling	$24,000	30 samples/day	1x or 2x/year
Discrete WQ Monitoring	$7,000	14 stations in situ	
Ichthyoplankton	$26,000	14 stations	Bimonthly (Apr-Sep) and Monthly (Oct-Mar)
Finfish Sampling	$21,000	14 stations	Bimonthly (Apr-Sep) and Monthly (Oct-Mar)
Epibenthic Egg Sampling	$21,000	14 stations	Monthly (Jan-Mar)

Note: Other testing parameters and costs will need to be determined in partnerships with multiple agencies and environmental groups.

Legal
Additional sampling will require consultation with regulatory agencies and permission from property owners (*e.g.*, NPS). It will be important to clearly distinguish between monitoring performed to meet permitting requirements and other monitoring efforts.

RECOMMENDATION

Water quality constituents that are currently sampled by the NYCDEP as part of the ongoing Harbor Survey Program are fairly extensive. After reviewing the sampling programs of other harbor estuaries and the goals of the JBWPP, NYCDEP in the short term will review the potential to expand its current monitoring program to include Sediment Profile Imagery, Pore Water Analysis, Benthic Habitat Analysis, Moored Water Quality Sensors, Mobile Water Quality Sampling, Discrete Water Quality Monitoring, Ichthyoplankton Sampling, Finfish Sampling and Epibenthic Sampling in a number of areas. Additional monitoring needs to be a collaborative effort among multiple entities, with appropriate funding identified and information sharing of research and monitoring data collection. See *Implementation Strategies* below for a description of these efforts.

IMPLEMENTATION STRATEGIES

Enhanced Monitoring Plan

NYCDEP based on this review, will develop an enhanced holistic water quality and ecosystem monitoring program to include some of the items listed below. The monitoring program will be coordinated with other entities conducting sampling within the Bay (see *Development of Partnerships and Funding Sources* below). Enhancements will include the following as detailed above:

1. **Potential Additional Water Quality Sampling**: the following parameters will be part of an enhanced program:

   - particulate organic carbon;
   - particulate organic nitrogen;
   - particulate organic phosphorus;
   - biogenic silica;
   - dissolved organic carbon;
   - dissolved organic nitrogen; and
   - dissolved organic phosphorus.

2. **Potential Sediment Sampling:** This type of sampling and analysis is highly specialized and would have to be completed and funded in partnership with other agencies and entities.

3. **Potential Biological and Ecosystem Monitoring:** Parameters such as algae enumeration and identification, SAV, as well as benthic biological indicators will be added.

4. **Salt Marsh Island Monitoring**: This effort is outside of NYCDEP's control and the monitoring of wetland biomass production; extent of marsh coverage from year to year; wetland elevation monitoring; and sediment sampling within marsh islands would need to continue by others. However, NYCDEP will assist in some of the data collection andgeographic information systems (GIS) analysis as appropriate and as feasible. Further coordination with multiple agencies and environmental groups is necessary before finalizing extent of effort.

Schedule: Enhancement program will be developed by October 2008.

Cost: To be determined based on proposed enhancements.

Other Potential Ecosystem Monitoring

Additional research and monitoring efforts are needed to adequately detail the environmental conditions of the Bay, its watershed and to provide feedback mechanisms that give an indication of how well current and past remediation efforts are functioning to improve ecological conditions and at what level and what factors may be limiting its ability to function properly. Research needs should be identified in collaboration with academic institutions, the public sector, and environmental organizations. The program should incorporate research on water quality issues, sediment, and upland vegetation (perimeter of the Bay and watershed) salt marsh islands, aquatic and benthic biota. Develop a list of research needs within the following categories:

1. Aquatic ecology
2. Coastal geomorphology
3. Plant ecology
4. Wildlife ecology
5. Natural resources management
6. Resource protection, planning and maintenance; and
7. Watershed-wide ecosystem monitoring.

Development of Partnerships and Funding Sources

A collaborative effort between local academic institutions and government agencies is essential to adequately address the enormous scope and complexity of the interacting ecosystems of the Bay and watershed and NYCDEP strongly encourages the development of such a program.

The Jamaica Bay Institute (JBI) maintains a database inventory of known studies performed on the Bay over the last 25 years or so. Some of the studies are outdated and could be updated by taking advantage of the great refinements in technology. Other studies could have benefited from better access to previous studies had they been inventoried. To help close this gap, the JBI has contracted with Queens College to develop a Research Opportunities Catalog that is modeled after a similar undertaking at the Cape Cod National Seashore. The document, "Research Opportunities in the Natural and Social Sciences at Cape Cod National Seashore," is being reviewed by Queens College to develop a report that would highlight the specific research and data gap needs within the boundaries of Jamaica Bay.

The following quote from this report sums up the need for collaboration rather nicely:

> ***"The diversity, complexity and sheer magnitude of wildlife, vegetation and natural processes occurring within the boundaries of Cape Cod National Seashore dictate a collaborative approach to research and resource monitoring at the park. The National Park Service simply cannot meet all of its research needs alone and thus we seek to expand our research partnerships with individuals, universities, public agencies and non-governmental organizations"*** **(NPS 2002).**

This is not only true for the NPS resources at Cape Cod, but can be said of all agencies and groups that have jurisdiction or regulation over Jamaica Bay. The task at hand is simply too large for any one entity to manage alone. A comprehensive and coordinated team effort is required.

In addition, as discussed in Chapter 7, "Implementation and Coordination," it is recommended that a steering committee be established to guide the implementation of Water Quality and Ecological Restoration strategies. A key role of this committee could be to coordinate monitoring efforts, track monitoring results, and identify additional data needs.

In addition, extensive work with academic institutions to develop a watershed based curriculum and direct research opportunities of faculty and students to help fill existing data gaps will provide valuable information that could potentially guide future restoration efforts and research needs.

Track Endocrine Disrupter Issues

Endocrine-disrupting compounds (EDCs), pharmaceutical and personal care products (PPCPs), and pharmaceutically active compounds (PhACs) are included under this broader category of chemicals and compounds called microconstituents. Microconstituents can make their way into the environment through a variety of routes, such as industrial discharges, wastewater treatment plant (WWTP) effluent, runoff from agricultural and feedlot operations, and other nonpoint sources that are more difficult to quantify. Compounds that have most often been implicated in endocrine disruption in aquatic organisms are the natural estrogens estrone (E1) and estradiol (E2), which are excreted by all humans; the synthetic estrogen ethinylestradiol (EE2), which is the active ingredient in birth control pills; and nonylphenol and octylphenol. The Stony Brook University work within Jamaica Bay has primarily focused on nonylphenol ethoxylates (NPEO). NPEOs are high production volume surfactants which have been used as detergents, wetting agents and emulsifiers in commercial and industrial products for more than 50 years. The issue of NPEO persistence and availability has been controversial and sparked considerable research.

Using the procedures of the federal advisory committee, developed by the Endocrine Disruptor Screening and Testing Authority (EDSTAC), one study placed the cost range to screen and test for many compounds to be approximately $200,000 and $1,000,000. Developing a screening and testing program that is designed to test for potentially thousands of compounds is extremely challenging. In addition, once screened and tested for, the removal methods for each compound are so varied that a separate program for removal may be required for each compound or groups of compounds.

The USEPA recently released its draft list of chemicals for initial Tier 2 screening. While this list was developed with pesticides in mind, NYCDEP will closely monitor USEPA's guidance on this issue.

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